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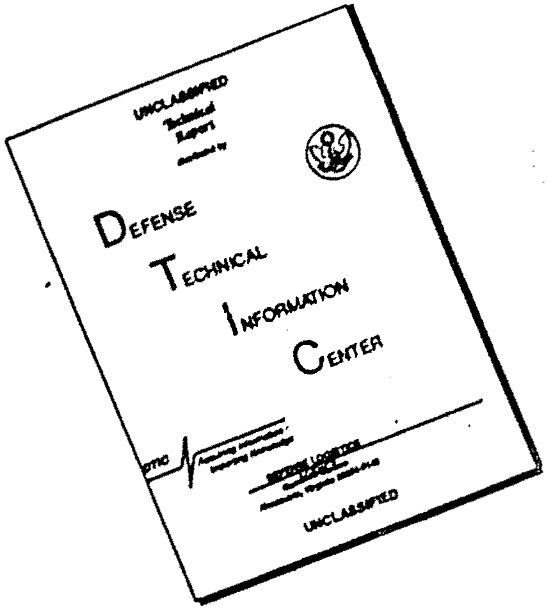

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C-123K C-1

FTC-TR-67-11

LIMITED PERFORMANCE AND STABILITY AND CONTROL TESTS

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Foreword....

This report contains the results of limited performance and stability and control tests performed on C-123K, USAF S/N 54-581 at the Fairchild-Hiller Corporation, Hagerstown, Maryland and Olmsted Air Force Base, Pennsylvania, between 3 October 1966 and 26 January 1967. The tests were conducted under Air Force Flight Test Center (AFFTC) Project Directive 66-104, 16 June 66. The program structure was 921A and the AFFTC priority was 25.

The authors of this report wish to express their appreciation to Gail R. Parcher, Captain USAF, for his engineering assistance in preparing this report and to Harry F. Wadsworth, Major USAF, Oscar G. Diessner, Captain USAF, and Francis R. McGeehan, MSgt USAF, of the Fairchild Defense Contract Administration Service field office who acted as crew members during this evaluation.

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This technical report has been reviewed and is approved.
31 July 1967

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Abstract...

The purpose of this C-123K test program was to obtain quantitative performance data and to qualitatively evaluate stability and control characteristics. The test aircraft was a C-123B modified to the C-123K configuration by the Fairchild-Hiller Corporation. Principal changes included the installation of a pylon-mounted J85-GE-17 engine under each wing, an improved modulated antiskid brake system and high performance wheels, a Monitair angle of attack/stall warning system, and the addition of the systems, instrumentation, structure, and controls required by the jet engine installation. Test results indicated a substantial improvement in takeoff and climb performance over that of the C-123B aircraft. Takeoff ground and air distances were slightly longer than those presented in the C-123K Flight Manual. Differences in flight test and Flight Manual climb performance were not great enough to warrant changing the Flight Manual. Landing ground distances obtained during this evaluation were slighly shorter and total distances were slightly longer than those presented in both the C-123B and C-123K Flight Manuals. The following performance was obtained for a gross weight of 60,000 pounds with the cg at the forward limit the takeoff ground roll was 1,240 feet and the total distance to a 50-foot altitude was 2,080 feet; the rate of climb at sea level was 1,560 feet per minute and the time to climb from sea level to 25,000 feet was 26 minutes; the total landing distance over a 50-foot obstacle was 1,800 feet with maximum braking and reverse thrust. The ground roll was 950 feet for this condition. When only maximum braking was used, the ground roll increased to 1,350 feet. Addition of the jet engines resulted in a drag increase corresponding to a loss of approximately 7 KIAS for the same reciprocating engine power setting at an aircraft gross weight of 50,000 pounds and sea level standard day conditions, and best cruise airspeed. In general, stability and control characteristics were similar to those of the C-123B aircraft. The unsatisfactory lateral-directional characteristics made precise heading control impossible under turbulent conditions. The air minimum directional control speeds with one jet engine inoperative and the remaining jet engine at military rated thrust (symmetric reciprocating engine power) were below the zero thrust stall speeds for the gross weights tested. With one reciprocating engine inoperative, the minimum control speed was 8 knots faster than that shown in the Flight Manual. Air minimum control speeds were unaffected by symmetric changes in jet thrust. The airspeed calibration obtained during this evaluation was significantly different from that presented in the Flight Manual. The Monitair angle of attack/stall warning system provided adequate artificial stall warning in all configurations and conditions tested. Use of the stall margin indicator during initial climb and landing approaches resulted in more precise speed control than was possible by use of the airspeed indicator alone.

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*Due to the limited distribution requirements of appendix III, it will be published in a separate volume. Copies can be obtained by writing to AFFTC/FTTEE-3 Edwards Air Force Base, California.

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LIST OF ABBREVIATIONS AND SYMBOLS

Item	Definition	Units
acft	aircraft	- - -
ADI	antidetonation injection	- - -
A_f	acceleration factor	dimensionless
AFR	Air Force Regulation	- - -
AFFTC	Air Force Flight Test Center	- - -
AVGAS	aviation gasoline	- - -
b	wingspan	ft
BHP	brake horsepower	550 ft-lb/sec
BHP_{iw}	generalized brake horsepower	HP
C	centigrade	- - -
CAT	carburetor air temperature	deg K, deg C
C_D	airplane total drag coefficient	dimensionless
cg	center of gravity	pct MAC
CHT	cylinder head temperature	deg C
C_L	airplane lift coefficient	dimensionless
C_p	power coefficient	dimensionless
$C_{P_{THP}}$	power coefficient	dimensionless

Item	Definition	Units
dc	direct current	amperes
deg	degrees	- - -
e	airplane efficiency factor	dimensionless
E	total energy	ft-lb
EGT	exhaust gas temperature	deg C
ETHP	equivalent thrust horsepower	- - -
$ETHP_{iw}$	generalized equivalent thrust horsepower	- - -
E/W	specific energy	ft
FCF	functional check flight	- - -
FD	fuel weight density	lb/gal
F_e	engine ram drag	lb
F_g	gross thrust	lb
F_n	net thrust	lb
fpm	feet per minute	- - -
ft	feet	- - -
F_t	propeller compressibility correction factor	dimensionless
FU	fuel used	gal
g	acceleration due to gravity	32.17405 ft/sec^2
gph	gallons per hour	- - -
Hg	mercury	- - -
HP	horsepower	- - -
hr	hour	- - -
in.	inches	- - -
inop	inoperative	- - -
J	propeller advance ratio	dimensionless
K	Kelvin	- - -
KIAS	knots indicated airspeed corrected for instrument error	- - -
kt	knots	- - -
lb	pounds	- - -
M	flight or free stream Mach number	dimensionless
MAC	mean aerodynamic chord	in.
MAP	manifold absolute pressure	in. Hg
METO	maximum except for takeoff	- - -

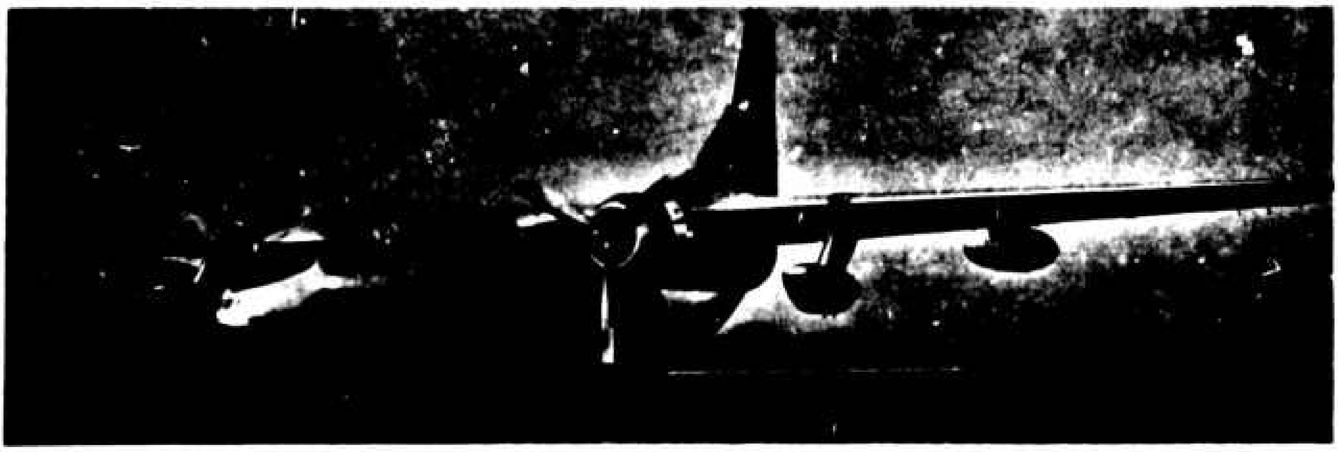
Item	Definition	Units
min	minute (of time)	- - -
MSDP	metering suction differential pressure	in. water
NAMPP	nautical air miles per pound of fuel	- - -
NAMT	nautical air miles traveled	- - -
N_e	number of engines operating	- - -
N_j	jet engine rotational speed	pct rpm
N_r	reciprocating engine rotational speed	rpm
OAT	ambient outside air temperature	deg C
P_a	atmospheric or ambient pressure	in. Hg
pct	percent	- - -
psi	pounds per square inch	- - -
P_t	total pressure	in. Hg
q	dynamic pressure	in. Hg
Q	engine torque pressure	psi
R/C	rate of climb	ft per min
$(\Delta R/C)_1$	correction to rate of climb for change in power	ft per min
$(\Delta R/C)_2$	correction to rate of climb for change in weight	ft per min
$(\Delta R/C)_3$	correction to rate of climb for change in induced drag due to weight variation	ft per min
rpm	revolutions per minute	- - -
S	wing area	ft^2
S_a	for takeoff, the air phase distance from lift-off to an altitude of 50 or 200 feet as specified; for landing, the air phase distance from an altitude of 200 or 50 feet, as specified, to touchdown	ft
S_{a_t}	test day air phase distance, corrected for wind	ft
$S_{a_{t_w}}$	test day air phase distance, not corrected for wind	ft
sec	second (of time)	- - -
S_g	ground roll distance	ft
S_{g_t}	test day ground roll distance, corrected for wind	ft
$S_{g_{t_w}}$	test day ground roll distance, not corrected for wind	ft
S/N	serial number	- - -

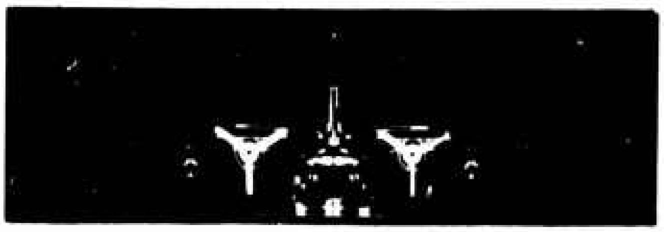
Item	Definition	Units
S_t	for takeoff, total distance from brake release to 50 or 200 feet as specified; for landing, total distance from 200 or 50 feet, as specified, to stop on the runway	ft
t	time	sec
T_a	ambient temperature	deg K
t_f	fuel temperature	deg C
THP	thrust horsepower	HP
TOP	torque oil pressure	psi
TSFC	thrust specific fuel consumption	lb per hr per lb
T_t	total temperature	deg K
USAF	United States Air Force	- - -
V_c	calibrated airspeed	kt
V_g	ground velocity as determined from phototheodolite data	kt
V_{ic}	indicated airspeed corrected for instrument error (not corrected for position error)	kt
V_{iw}	generalized airspeed parameter	kt
V_{mc}	minimum directional control speed	KIAS
V_s	stall speed	KIAS
V_t	true airspeed	kt
V_w	wind velocity	kt
ΔV_{pc}	correction for airspeed position error	kt
W	airplane gross weight	lb
W_a	engine airflow	lb per sec
W_f	fuel flow	lb per hr
W_{iw}	standard weight for generalized power and airspeed parameters	lb
δ_a	relative pressure or ambient pressure ratio ($P_a/P_{a_{SL}}$)	dimensionless
δ_{t_2}	compressor inlet pressure ratio ($P_{t_2}/P_{a_{SL}}$)	dimensionless
η_p	propeller propulsive efficiency	dimensionless
θ_a	relative temperature or ambient temperature ratio ($T_a/T_{a_{SL}}$)	dimensionless
θ_{t_2}	compressor inlet temperature ratio ($T_{t_2}/T_{a_{SL}}$)	dimensionless

Item	Definition	Units
ρ	air density	slugs/ft^3
σ	relative air density or air density ratio (ρ/ρ_{SL})	dimensionless

Subscripts

a	ambient	- - -
i	indicated	- - -
ic	indicated corrected for instrument error	- - -
LO	lift-off	- - -
s	standard day	- - -
SL	sea level	- - -
t	test day conditions	- - -
TD	touchdown	- - -
50	50 feet altitude	- - -
2	jet engine compressor inlet condition	- - -





INTRODUCTION

This report presents the results of the limited flight test program conducted on C-123K USAF S/N 54-581 by the Air Force Flight Test Center (AFFTC). The purpose of the test program was to obtain quantitative performance data and to qualitatively evaluate the aircraft's stability and control characteristics. The tests were conducted by AFFTC personnel at the Fairchild-Hiller Corporation facility in Hagerstown, Maryland, and at Olmsted Air Force Base, Pennsylvania, between 3 October 1966 and 26 January 1967 with 37 flights and a total time of 59 hours 20 minutes flown. Two additional flights were flown on 1 June 1966 for a time of 2 hours 5 minutes to obtain base-line drag data prior to the modification of the test aircraft to the C-123K configuration. All tests were accomplished with the external drop tanks installed.

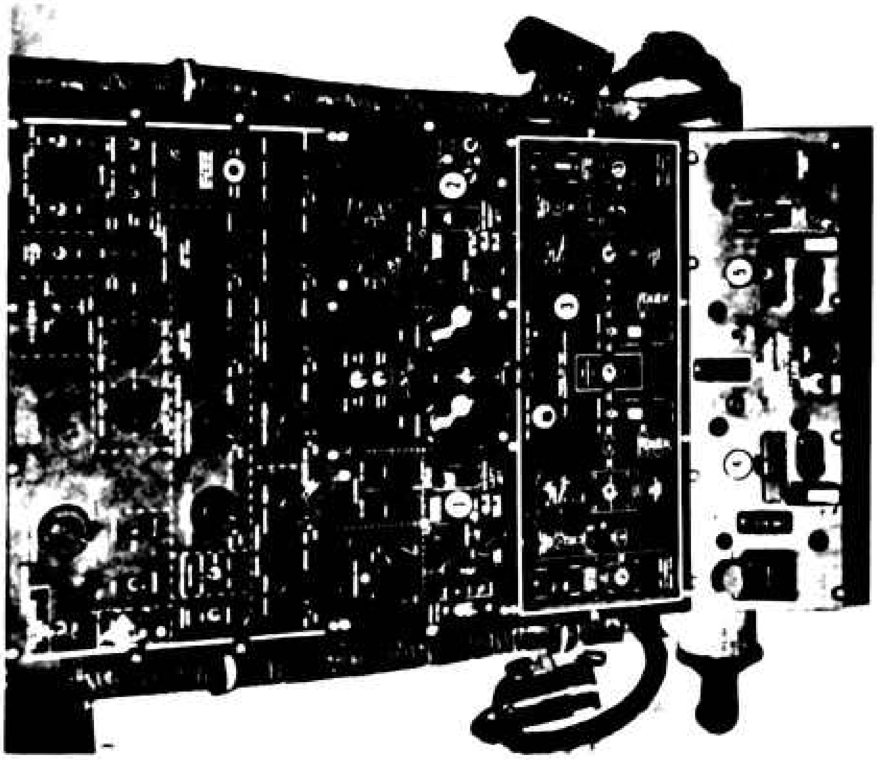
The angle of attack/stall warning system manufactured by the Monitair Corporation was evaluated in conjunction with these tests. A summary report on the Monitair system was sent to the prime air materiel depot, Warner-Robins Air Materiel Area, on 31 March 1967. The final report on the Monitair system is presented as appendix IV of this report. The conclusions and recommendations pertaining to the Monitair system are contained in the Conclusions and Recommendations section of the main report.

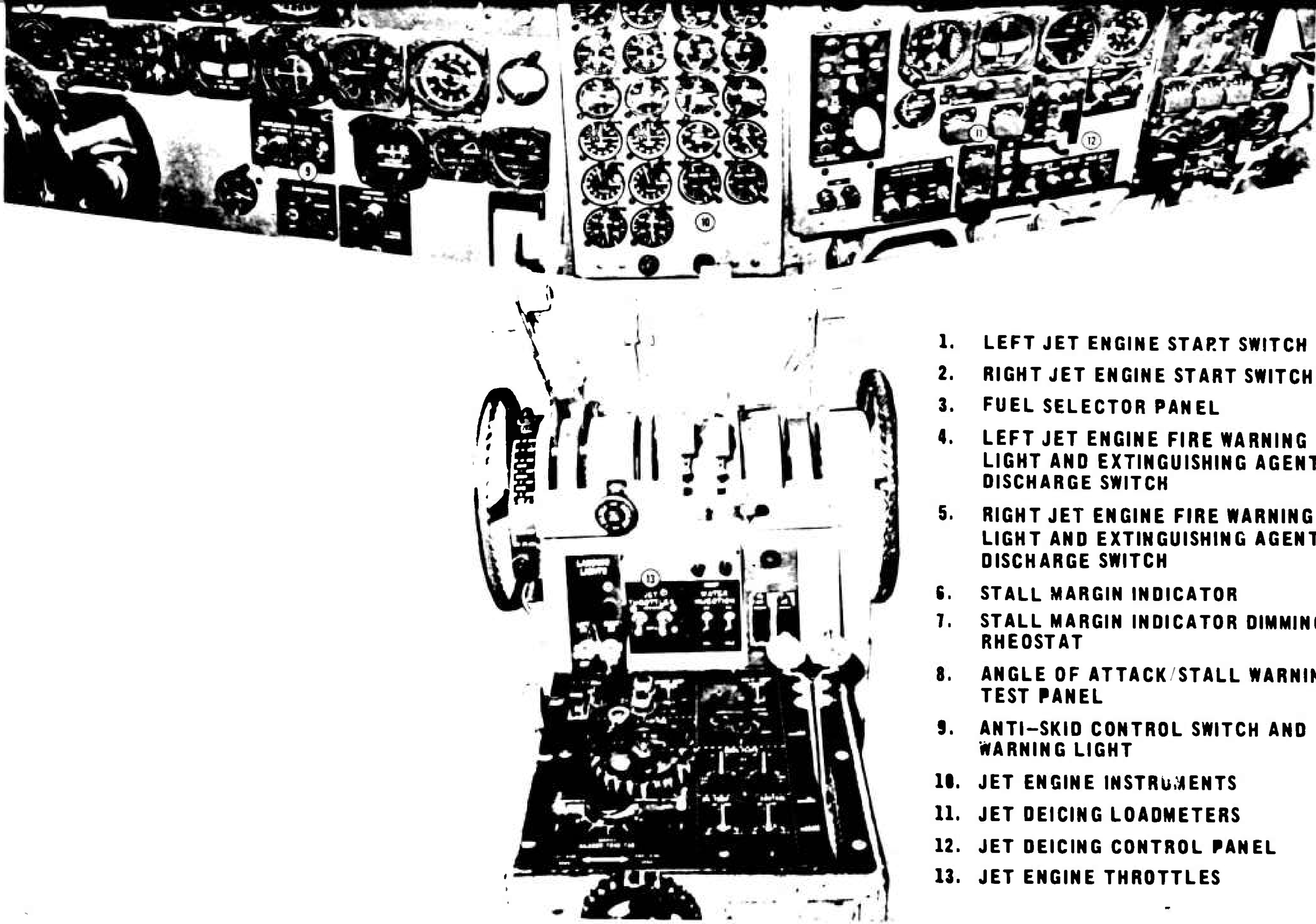
The test aircraft was a C-123B, two-engine, high wing, assault transport modified by the Fairchild-Hiller Corporation to the C-123K configuration by the installation of a pylon-mounted J85-GE-17 turbojet engine under each wing to provide additional thrust. Other changes included in the modification were:

1. The installation of a modulated antiskid brake system utilizing modified Goodyear Type PP2188 brakes and high performance wheels.

2. The installation of the Monitair angle of attack/stall warning system.

3. The addition of the systems, instrumentation, structure, and controls required by the jet engine installation which included strengthening of the wing structure and wing flap and adding: jet engine starting controls to the engine start panel (figure 1); jet engine throttle switches to the control quadrant (figure 1); jet engine instruments to the lower center portion of the instrument panel (figure 1); jet engine fire warning and fire extinguisher systems and controls (figure 1); jet engine anti-icing controls to the copilot's instrument panel (figure 1); and an additional boost pump in each nacelle fuel tank, plumbing and shut-off valves.





1. LEFT JET ENGINE START SWITCH
2. RIGHT JET ENGINE START SWITCH
3. FUEL SELECTOR PANEL
4. LEFT JET ENGINE FIRE WARNING LIGHT AND EXTINGUISHING AGENT DISCHARGE SWITCH
5. RIGHT JET ENGINE FIRE WARNING LIGHT AND EXTINGUISHING AGENT DISCHARGE SWITCH
6. STALL MARGIN INDICATOR
7. STALL MARGIN INDICATOR DIMMING RHEOSTAT
8. ANGLE OF ATTACK/STALL WARNING TEST PANEL
9. ANTI-SKID CONTROL SWITCH AND WARNING LIGHT
10. JET ENGINE INSTRUMENTS
11. JET DEICING LOADMETERS
12. JET DEICING CONTROL PANEL
13. JET ENGINE THROTTLES

FIGURE 1 COCKPIT LAYOUT

The aircraft was powered by two R-2800-99W reciprocating engines rated at 2,500 brake horsepower (BHP) each with water injection for takeoff and 1,900 BHP maximum except takeoff (METO) power. The reciprocating engines drove Hamilton Standard three-bladed, full feathering, reversible, constant speed, Type 43E60-607 propellers. Jet thrust augmentation was provided by the two pylon-mounted J85-GE-17 engines with an uninstalled static thrust of 2,850 pounds for sea level standard day conditions. Fuel used by all engines was aviation gasoline (AVGAS) grade 115/145.

The maximum gross weight of the aircraft was limited to 60,000 pounds by the landing gear structure. Gross weight and center of gravity (cg) were controlled in the test aircraft by use of lead shot ballast and two 5,600-pound capacity water ballast tanks installed in the cargo compartment.

Test instrumentation installed and maintained by Fairchild-Hiller consisted of a photopanel located in the cargo compartment (figure 1, appendix II). A list of the installed instrumentation is contained in appendix II.

TEST AND EVALUATION

CREW STATION AND SYSTEMS EVALUATION

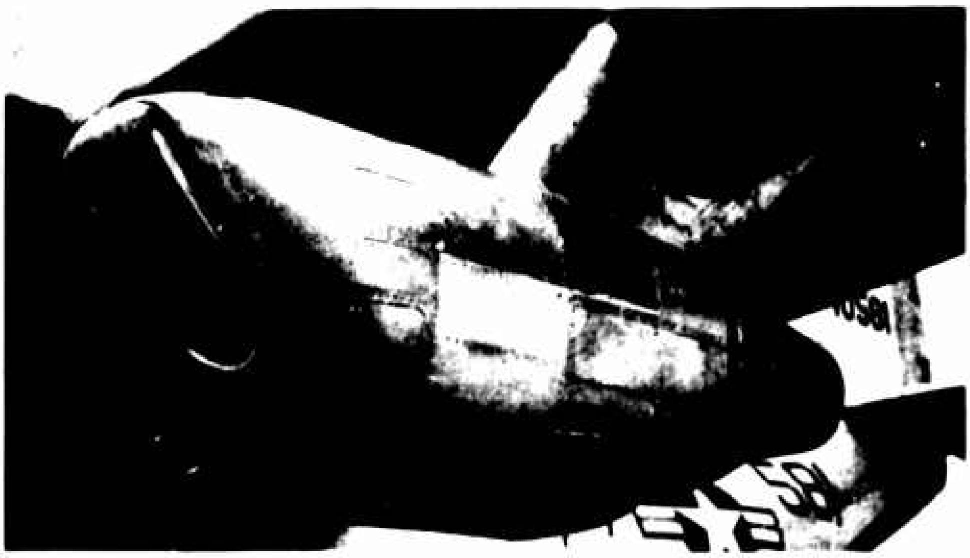
Entrance to the aircraft and the location of all crew stations remained the same as in the C-123B. Changes to the cockpit configuration mainly consisted of controls and instruments for the jet engines, the antiskid system, and the Monitair angle of attack/stall warning system.

The REPLENISH PROP OIL panel was moved to the pilot's instrument panel. In this location, the propeller oil warning lights were partially hidden from the pilot by the control column. The panel should be moved to a location where the pilot will have an unobstructed view of the warning lights. (R 2)[1]

No master fire warning light was installed in the test aircraft. All C-123K aircraft should be equipped with a master fire warning light located in a position visible to both pilots. (R 3)

The maximum allowable jet engine oil pressure for continuous operation was 60 pounds per square inch (psi). The Flight Manual stated that this limit may be exceeded for 5 minutes after starting, but not to exceed 185 psi; however, the test aircraft was equipped with a 0-100 psi indicator. All C-123K aircraft should be equipped with jet engine oil pressure indicators having a 0-200 psi range. (R 4)

[1] Numbers indicated as (R 2), etc., represent the corresponding recommendation number as tabulated in the Conclusions and Recommendations section of this report.



JET ENGINE STARTING AND OPERATION

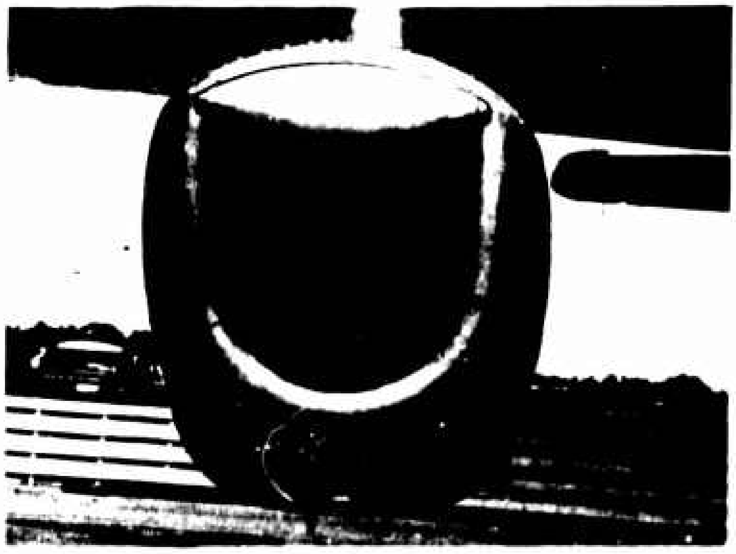
Starting and shutdown of each jet engine was controlled by a separate rotary switch located overhead on the engine start panel (figure 1). Some switch positions were unnecessary. Each switch was normally rotated through the CRANK TO 5% RPM and IGN TO 11% RPM positions directly to the FUEL TO 38% RPM position for starting. The detents at most positions were not sufficiently pronounced. This caused three inadvertent shutdowns while attempting to select the RUN position from the FUEL TO 38% RPM position. These switches were unsatisfactory. A simpler jet engine start switch and automatic start sequencing should be incorporated. (R 5)

In the event that automatic start sequencing is not incorporated, the jet engine starting procedure presented in the Flight Manual should be changed to allow selection of the FUEL TO 38% RPM position directly from the SHUTTER position. In addition the procedure should specify that the start switch should remain in the FUEL TO 38% RPM position until 35- to 38-percent jet engine revolutions per minute (rpm) is reached. (R 6)

The jet engine starter/generators began to generate current occasionally at speeds as low as 35-percent rpm. When the jet engine start switch was left in the FUEL TO 38% RPM position until the jet engine generator voltage exceeded that of the reciprocating engine generators, the reciprocating engine generator reverse current relays were energized. The primary and secondary direct current (dc) busses then received no power, and the flight emergency bus was powered by unregulated voltage from the jet engine generator. The confusion and distraction caused by this unsatisfactory condition could be very serious during night weather operation. Reverse current protection should be added to the jet engine starter/generator circuitry. (R *7)[2]

Aircraft electrical power was inadequate to start both jet engines simultaneously, or to start one jet engine with the propeller and jet engine deicing system operating. During normal jet engine starts, both reciprocating engine generator loadmeters remained at maximum deflection for

[2]Asterisks denote safety of flight items.



several seconds. At least 10 jet engine starts were accomplished with one reciprocating engine (and its generator) shut down. No problems were encountered, but the capability of one reciprocating engine generator to sustain the required load appears to be marginal. The aircraft electrical system load capability should be increased. (R *7)

The jet engine throttle switches were located on the center pedestal aft of the throttle quadrant (figure 1). This location was slightly inconvenient. Jet engine thrust regulation at other than idle and full power was difficult due to rapid throttle actuator operation. Annoying yawing moments were introduced during throttle operation because the actuators did not operate in unison. The jet engine throttle controls and their location were acceptable since the engines were used only for thrust augmentation and were therefore normally operated at idle or full power.

The jet engine fuel supply system was unsatisfactory. The jet engine boost pumps were located so far forward in the nacelle fuel tanks that they would cavitate during initial climb following a maximum performance takeoff with the nacelle tanks approximately half full. Three jet engine flameouts occurred during steep climbs with 2,000 to 2,200 pounds of fuel in each nacelle tank. The nacelle tank/boost pump configuration should be changed so that maximum performance takeoffs can be performed without danger of jet engine fuel starvation. In the interim, the Flight Manual should warn that jet engine flameouts have occurred during maximum performance takeoffs and climbs with less than 2,200 pounds of fuel in each nacelle tanks. (R 9, R *10)

Fuel transfer from the pylon tanks to the nacelle tanks could not be accomplished with the jet engines operating. When transfer was attempted during jet engine operation, a reverse flow of fuel occurred and fuel was pumped from the nacelle tank to the pylon tank. When the pylon tanks were full, fuel could be pumped overboard. The fuel system should be changed to allow fuel transfer during jet engine operation. (R 11)

Electrical heating elements installed in the air inlet door and air inlet lip area provided anti-icing protection to the jet engine pod when the jet engines were not operating. Power for this phase of anti-icing was supplied by the aircraft 28-volt dc flight emergency bus. Electrical power for all other aircraft deice and anti-ice systems was supplied by the aircraft primary dc bus. Operation of the jet engine pod anti-ice system under emergency conditions during which reciprocating engine generator power is unavailable would result in premature loss of battery power. Electrical power for the jet engine pod anti-icing system should be supplied from the aircraft primary dc bus. (R 12)

On several occasions during the test program, it became necessary to start and operate the jet engines at altitudes up to 25,000 feet. Jet engine starts were satisfactory at all altitudes tested, but in some cases the engines would not accelerate to normal idle rpm after start nor would the engines respond to throttle actuation. At altitudes in excess of approximately 14,000 feet, running the throttle actuator to the fully retarded position resulted in engine speeds as low as 28-percent rpm (idle speed on the ground was approximately 50-percent rpm). The engines could not be accelerated above this low idle speed at normal level flight airspeeds. If the indicated airspeed was increased to approximately 170 knots indicated airspeed (KIAS) by diving, the jet engines would accelerate normally. General Electric recommended that jet engine speed be maintained above 70-percent rpm for altitudes in excess of 5,000 feet. Engine idle speed data presented in figure 18 of the J85-GE-17 Model Specification, reference 1, and experience gained during this evaluation indicated that operating the jet engines at this high idle speed was unnecessary. A study should be made to determine a practical high altitude jet engine idle speed. In addition, a NOTE should be placed in the Flight Manual to inform the pilot of these jet engine acceleration characteristics at high altitudes. (R 8)

TAKEOFF PERFORMANCE

Maximum performance takeoffs were conducted at gross weights of 45,000 and 60,000 pounds from the hard-surfaced runway at Hagerstown, Maryland. All takeoffs were performed with the wing flaps in the TAKEOFF (20 degrees) position and the center of gravity at the forward limit (20.6-percent mean aerodynamic chord (MAC)). Takeoffs at 60,000 pounds were made with and without the antidetonation injection (ADI) on. The takeoff data were recorded by a Fairchild flight analyzer operated by Fairchild-Hiller personnel. The data were corrected to standard day, sea level, no wind conditions, and are presented in figure 4, appendix I.

The takeoff technique employed consisted of starting the jet engines just prior to taking position on the runway in order to minimize the possibility of foreign object ingestion and to reduce the amount of fuel used during ground operations. After the aircraft was lined up on the runway, the brakes were set and takeoff power was set on the reciprocating engines. The jet engine throttles were then advanced to military rated thrust. In most cases, the brakes held at full power. In the cases in which the brakes did not hold, jet engine acceleration was rapid enough that military rated thrust was reached by the time the pilot realized the aircraft was moving.

After brake release, directional control was maintained with the nosewheel steering and rudder. The pilot kept his hand on the nose steering wheel until just prior to rotation. Due to high aircraft acceleration, it was necessary to initiate application of full up elevator approximately 10 knots below the aim takeoff airspeed. Initial climb was established by reference to the Monitair system stall margin indicator. Maximum performance was achieved by attaining a stall margin indication of 1.1 V_s as soon as possible after lift-off and holding this indication until obstacle clearance. Aircraft acceleration was such that use of this technique resulted in a normal acceleration of approximately 1.2 g during the air phase of the takeoff (lift-off to 50 feet). Aircraft drag increased during gear retraction due to the gear door configuration. In addition, the time required for landing gear retraction was such that the aircraft was well above 50 feet before gear retraction was complete. For these reasons, no attempt to raise the landing gear was made until the aircraft was above 50 feet.

Tests were conducted to determine the minimum nosewheel lift-off speed for a gross weight of 60,000 pounds and a cg location of 20.6-percent MAC with maximum wet reciprocating engine power, and to determine the effect of jet engine thrust on this speed. A nosewheel lift-off indicator light was installed for these tests. The light was wired through the existing nose gear oleo switch and illuminated whenever the nose gear strut was extended. Test results indicated that the minimum nosewheel lift-off speed with the jet engines inoperative was approximately 75 KIAS. With the jet engines at military rated thrust, this speed increased to approximately 79 KIAS. Ground observers reported that following initial nose gear lift-off the aircraft appeared to rotate to a pitch attitude in which the nose gear was approximately 1 foot above the runway. Without any change in control column position the aircraft appeared to pause in this attitude before continuing to rotate to the lift-off attitude.

The nosedown pitching moment about the main landing gear due to the jet engine thrust coupled with a forward cg condition resulted in insufficient elevator power to rotate the aircraft to the takeoff attitude at the Flight Manual recommended takeoff speed. This lack of elevator power was discussed in both the C-123B and C-123K Flight Manuals. Maximum performance takeoff charts were presented in the C-123B Flight Manual for both forward and aft cg conditions. These charts indicated that a forward cg condition resulted in as much as a 50-percent increase in ground run. Although the effect of cg on the rotation and takeoff airspeeds was discussed in the text, the takeoff speeds tabulated on the performance charts were the same for all cg conditions. Only one maximum performance takeoff chart was presented in the C-123K Flight Manual. No reference to cg position was made on this chart and it therefore implied that the performance and takeoff speeds presented were valid for all cg positions. A comparison of the Flight Manual takeoff performance and that obtained during this evaluation for a forward cg condition is presented in table I.

No mid or aft cg takeoff data were obtained during this evaluation and therefore the effect of cg on rotation airspeed was not determined. However, comparison of the takeoff speeds presented in both the C-123B and

TABLE I
MAXIMUM PERFORMANCE TAKEOFF COMPARISON
RECIPROCATING ENGINES – MAXIMUM WET POWER
JET ENGINES – MILITARY RATED THRUST

	FLIGHT MANUAL DATA [2]					C-123K FLIGHT TEST DATA [1,2]		
		C-123K		C-123B[1]				
GROSS WEIGHT (lb)	INDICATED AIRSPEED AT LIFT-OFF (kt)	GROUND DISTANCE (ft)	TOTAL DISTANCE (ft)	GROUND DISTANCE (ft)	TOTAL DISTANCE (ft)	INDICATED AIRSPEED AT LIFT-OFF (kt)	GROUND DISTANCE (ft)	TOTAL DISTANCE (ft)
45,000	68	580	1,000	1,160	1,550	74	600	1,170
60,000	80	1,190	1,800	2,450	3,400	87	1,240	2,080

NOTE: 1. cg at forward limit (20.6-percent MAC). C-123B aircraft do not have auxiliary jet engines installed.

2. Flight Manual takeoff air distances are based on a climbout airspeed corresponding to 106 percent of the takeoff power stall speed. Flight test air distance are based on a climbout airspeed corresponding to a stall margin indication of 1.1 V_s.

C-123K Flight Manuals and the data presented in the C-123B flight test report, reference 2, indicated that the C-123K Flight Manual takeoff speeds were valid for a mid to aft cg condition if the jet engines were inoperative. Maximum performance takeoff charts for the jet engines operating for both forward and aft cg conditions should be added to the Flight Manual. The takeoff performance for the aft cg condition should be based on the current Flight Manual takeoff speeds increased by 4 knots to compensate for the nosedown pitching moment about the main landing gear due to the jet engine thrust. Since reference 2 indicated at a forward cg condition result in a 3- to 5-knot increase in nosewheel liftoff speed, the forward cg takeoff performance should be based on the current Flight Manual takeoff speed increased by 8 knots to compensate for the nosedown pitching moment due to the jet engine thrust coupled with a forward cg condition. Both charts should reflect the performance levels contained in this report. (R *13)

As mentioned previously, speed control during initial climb was maintained by reference to the stall margin indicator. The Flight **Manual recommended conducting ini-**tial climb at 106 percent of computed takeoff power stall speed. However, use of that procedure resulted in flight with the stick shaker operating and consequent masking of any aerodynamic stall warning. Use of climb speeds corresponding to a stall margin indication of 1.1 V_s provided climb without the stick shaker operating and provided a significant safety margin. A stall margin indication of 1.1 V_s should be maintained during initial climb following a maximum performance takeoff. Further comments concerning the use of the stall margin indicator during initial climb are contained in appendix IV. (R 14)

Plans to conduct takeoff tests from a sod field were cancelled because extensive snow and rain rendered all available fields in the area unusable.

CLIMB PERFORMANCE

■ CLIMB SPEED DETERMINATION

Sawtooth climb tests were performed in the cruise configuration at altitudes of 5,000 and 15,000 feet and gross weights of 60,000 pounds and 45,000 pounds.

Test results indicated that over the airspeed range tested, variations in airspeed had relatively little effect on rate of climb. The Flight Manual recommended climb speed of 130 KIAS for all gross weights and altitudes with all engines operating was up to 9 knots faster than the optimum climb speed as determined from these tests. For the conditions tested, however, climb at the Flight Manual recommended speed resulted in a maximum rate of climb degradation of only 2.9 percent (50 feet per minute (fpm)). Due to the improved engine cooling, the simplicity provided by maintaining a constant airspeed throughout the climb, and the insignificant climb performance degradation, the Flight Manual recommended climb speed (130 KIAS) should be used for climbs with all engines operating. The sawtooth climb data are presented in figures 5 and 6, appendix I. (R 15)

CONTINUOUS CLIMBS

Two continuous climbs to 25,000 feet altitude were flown at each of two engine start gross weights, 48,000 and 60,000 pounds, using METO reciprocating engine power, military rated thrust on the J85 turbojet engines, and a climb speed of 130 KIAS. In addition, two continuous climbs were flown at an engine start gross weight of 56,000 pounds with the left reciprocating engine inoperative and the propeller feathered, METO power on the right reciprocating engine, and at the Flight Manual recommended climb speed schedule. The J85 turbojet engines were operated at military rated thrust during these tests. Data were taken up to 12,000 feet while using low blower on the reciprocating engines. The climb was then restarted at 9,000 feet and was continued in high blower. The cowl flaps for the operating reciprocating engines were set in the TAKEOFF position and the oil cooler was full open (COLD). All left engine cooling devices were closed in the left reciprocating engine inoperative case. Below the critical altitude, it was necessary to continually reposition the reciprocating engine throttles in order to maintain METO power.

All climbs were flown perpendicular to the forecast wind direction and in the cases where two climbs were flown under the same conditions, alternate headings were used in an attempt to minimize wind gradient effects. There was strong evidence that wind gradients were present, however, as can be noted by comparing climbs conducted under the same conditions. Correlation between continuous climb data, sawtooth climb data, and rates of climb calculated from level flight data was poor in some cases, but it was felt that the poor data correlation was due to the wind gradients for which no corrections have been made. However, data correlation is sufficient to indicate that the data fairings represent actual performance levels for the C-123K aircraft.

Manifold pressure data obtained during the continuous climbs were significantly lower than those presented in the Specific Operating Instructions for the R-2800-99W engine, reference 3. The reason for this discrepancy was not determined and therefore manifold pressure data fairings presented were extracted from reference 3.

Continuous climb performance observed during this evaluation was slightly lower than that presented in the Flight Manual. However, the difference was not great enough to warrant changing the Flight Manual climb performance data. A climb performance summary is shown in table II. Continuous

TABLE II

CLIMB PERFORMANCE SUMMARY

No. RECIPROCATING ENGINES OPERATING, METO	2	2	1[1]
No. OF JET ENGINES OPERATING, MRT	2	2	2
ENGINE START GROSS WEIGHT[2] (lb)	60,000	48,000	56,000
CLIMB SPEED (KIAS)	130	130	56 120
SEA LEVEL RATE OF CLIMB (fpm)	1,560	2,080	920
SERVICE CEILING[3] (ft) (R/C - 100fpm)	27,500	31,000	22,800
TIME TO CLIMB TO SERVICE CEILING (min)	36	30	49
CRITICAL ALTITUDE LOW BLOWER (ft)	7,100	7,100	6,600
CRITICAL ALTITUDE HIGH BLOWER (ft)	15,900	15,900	14,700

NOTES: 1. Left reciprocating engine inoperative–propeller feathered, all cooling devices closed.

2. 500 pounds of fuel allowed for engine start, taxi, takeoff, and acceleration to climb speed

3. Extrapolated from flight test data.

climb data corrected to standard day conditions are shown in figures 7 through 9, appendix I.

LEVEL FLIGHT PERFORMANCE

Speed power tests were flown in the cruise configuration at altitudes ranging from 5,000 to 20,000 feet and gross weights from 45,000 to 60,000 pounds. These tests were flown to determine the drag of the C-123K and to define cruise speeds and range data. With the exception of one speed power test which was conducted with the jets operating at 90% RPM, all cruise configuration level flight performance tests were conducted with both reciprocating engines operating and both jet engines inoperative. The jet engine inlet doors were closed in all cases where the jet engines were inoperative. Corrections for cooling device drag were not required since all cruise configuration tests were flown with the cowl flaps faired (streamlined with the cowling) and the oil cooler doors in the COLD position. Drag data obtained during these tests were compared with similar data obtained for the test aircraft prior to its modification to the C-123K configuration. One speed power test was flown in the power approach configuration with the jet engines at idle.

For the level flight tests with the jet engines operating, jet engine rpm was set and remained constant while the airspeed was varied by adjusting only the reciprocating engine power. Reciprocating engine power was set by reference to the BHP-engine rpm schedules contained in the C-123B Flight Manual. After power was set and stabilized, fuel flow data were measured by using Stepper Motors timers and Revere flowmeters. The manual lean mixture setting used in this evaluation corresponded to that setting which resulted in a torque pressure which was 7 psi lower than that at best power mixture. Manual lean was used only below 1,300 BHP.

Power required data in the form of brake horsepower versus true airspeed (V_t) are presented in figures 10 through 18, appendix I. The equivalent thrust horsepower and airspeed data have been generalized to the form of $ETHP_{iw}$ and V_{iw} and are presented in figures 30 through 33, appendix I. The fairings in these figures have been cross plotted from the appropriate drag polars.

Specific range data (NAMPP) are presented in figures 19 through 25, appendix I. The solid line fairings on the NAMPP plots represent data cross plotted from the drag polars and the engine characteristic data. Corresponding NAMPP data fairings from the Flight Manual are also shown. It should be noted that the nautical air miles traveled per pound of fuel used reflects the fuel used by all of the operating engines.

Specific range data obtained in the cruise configuration indicated that recommended cruise speeds (the faster speed for 99 percent of maximum NAMPP) were as much as 7 percent (10 knots) slower than those presented in the Flight Manual for the conditions tested. The specific range at each recommended cruise speed was as much as 5 percent lower than that presented in the Flight Manual for the condition tested.

Comparison of figures 34 and 35 reveals that modification of the C-123B aircraft to the C-123K configuration resulted in an incremental drag coefficient increase of 0.0055. At an aircraft gross weight of 50,000 pounds, sea level standard day conditions, and at best cruise speed this drag increment corresponded to a loss of approximately 7 KIAS for the same reciprocating engine power setting. The Flight Manual specific range values should be changed to reflect the drag levels shown in this report and the fuel consumption data shown in the Flight Manual. (R 1)

A summary of the level flight performance obtained during this evaluation is presented in table III.

TABLE III
SUMMARY OF LEVEL FLIGHT PERFORMANCE
STANDARD DAY CONDITIONS
CRUISE CONFIGURATION
COWL FLAPS FAIRED – OIL COOLER COLD
RECIPROCATING ENGINES OPERATING
JET ENGINES – AS NOTED
PYLON TANKS ON

		C-123B		C-123K					
ALTITUDE (ft)		5,000	20,000	5,000	5,000	15,000	15,000	15,000	20,000
GROSS WEIGHT (lb)		50,000	40,000	50,000	60,000	55,000	55,000	45,000	45,000
CONDITION OF JET ENGINES		NOT INSTALLED		INOP	INOP	INOP	90-pct rpm	INOP	INOP
RECOMMENDED CRUISE SPEED[2] (KTAS)	FLT MAN.	141	162	138	147	164	214	154	165
	TEST	---[1]	---[1]	136	144	154	208	152	160
NAMPP AT RECOMMENDED CRUISE SPEED	FLT MAN.	0.1700	0.2060	0.1665	0.1370	0.1400	0.0598	0.1755	0.1780
	TEST	---[1]	---[1]	0.1605	0.1320	0.1370	0.0575	0.1683	0.1703
POWER REQUIRED AT RECOMMENDED CRUISE SPEED (BHP/ENGINE)	FLT MAN.	910	820	910	1,175	1,200	1,140	940	990
	TEST	960[3]	900[3]	1,000	1,280	1,245	1,260	1,010	1,060
METO POWER (BHP/ENGINE)		1,900	1,490	1,900	1,900	1,700	1,700	1,700	1,490
SPEED AT METO POWER (KTAS)	FLT MAN.	193	207	189	188	198	237	201	202
	TEST	192	207	183	179	189	226	195	193

NOTES: 1. Fuel flow data not available – no instrumentation

2. Recommended cruise was the highest speed at which 99 percent of maximum NAMPP was attained.

3. These power data are referred to Flight Manual recommended cruise speeds.

Reciprocating engine fuel flow data obtained during the level flight performance tests are presented in figure 49, appendix I. The data obtained with the mixture at the automatic rich setting were 3 to 13 percent lower than the fuel flow data presented in the Flight Manual for the same conditions. When manual leaning was used, the resulting fuel flow was 0 to 12.6 percent lower.

Jet engine fuel flow data were obtained at 90-percent rpm during level flight tests and at military rated thrust during continuous climb tests. These data are presented in figure 48, appendix I. The data obtained during stabilized flight agrees well with the General Electric estimated data.

LANDING PERFORMANCE

NORMAL LANDINGS

Although performance data were not acquired, numerous landing approaches and landings were conducted to determine the feasibility of using a constant stall margin indication for normal approaches. The stall margin indicator was used as the primary speed control instrument. The Flight Manual recommended approach speeds for normal landings were 30 knots faster than the power-off (zero thrust) stall speed. Results of these tests indicated that approach at a speed corresponding to a stall margin indication of 1.25 V_s with flaps up, and 1.3 V_s with flaps down 20 and 45 degrees was satisfactory. That procedure resulted in flaps up approaches ranging from 17 knots faster than stall speed at 45,000 pounds to 30 knots at 60,000 pounds; for LAND flaps (45 degrees) the approach speeds were 20 and 23 knots faster, respectively. The Flight Manual should be changed to recommend approach speeds corresponding to stall margin indications of 1.25 V_s for flaps up and 1.3 V_s for flaps down 20 or 45 degrees. (R 16)

Use of the stall margin indicator during landing approaches is further discussed in appendix IV.

MAXIMUM PERFORMANCE LANDINGS

Maximum performance landings were conducted for the conditions shown in table IV. All landings were conducted with the flaps in the FULL down position (60 degrees) and the cg located at 20.6-percent MAC. Landing approaches were flown with various engine power conditions as can be noted from table IV.

TABLE IV
MAXIMUM PERFORMANCE LANDING
TEST CONDITIONS
FULL FLAPS (60 deg)

GROSS WEIGHT (lb)	APPROX RECIP POWER	JET POWER	REVERSE THRUST
58,950	ZERO THRUST	IDLE	YES
58,700	ZERO THRUST	INOP	YES
59,200	ZERO THRUST	IDLE	No
46,400	ZERO THRUST	IDLE	No
43,950	IDLE	IDLE	YES

With the jet engines inoperative, the approach and flare techniques and handling characteristics were the same as those of the C-123B. Landings with the jet engines operating were slightly different. A tendency existed to reduce the reciprocating engine power too much when the jet engines were operating at idle during a maximum performance approach. If reciprocating engine power was reduced below the approximate zero thrust setting (16 inches Hg manifold absolute pressure (MAP) and 2,400 rpm), the stall speeds increased considerably above the zero thrust stall speeds tabulated on the Flight Manual landing performance charts. A few approaches and landings were performed with both the jet and reciprocating engines at idle using a stall margin indication of 1.2 V_s (power compensation switches were closed). These approaches were very steep and considerable care was required to complete the flare without stalling. After completion of the flare, the airplane floated a considerable distance before it touched down. Conversely, a much slower approach could have been flown if a shallow glide path and high reciprocating engine power had been used. Neither the slow, dragged in approach nor the idle power approaches are recommended due to the small margins of safety and the increased landing distances over an obstacle.

The Flight Manual recommended approach speeds for maximum performance landings were based on 115 percent of the zero thrust stall speed. During this evaluation it was determined that the full flap zero thrust stall speeds were approximately 3 knots lower than those presented in the Flight Manual. Because of this difference, the recommended maximum performance approach speeds tabulated in the Flight Manual were approximately equal to 120 percent of the actual zero thrust stall speeds of the C-123K. The stall margin indicator was set to agree with zero thrust stall speeds as determined during this evaluation. If full flap approaches were flown using the 1.15 V_s reference on the stall margin indicator, adequate stall margin was not available for flare and a stall could be encountered. Considering the effect of approach speed and engine power condition on aircraft handling qualities and performance, maximum performance approaches should be flown with a reciprocating engine manifold pressure of 18 to 20 inches of mercury and either a stall margin indication of 1.2 V_s or 120 percent of the zero thrust stall speed determined during this evaluation. When this technique was used, touchdown occurred at the recommended touchdown speeds shown in figures 38 and 39, appendix I. These speeds correspond to 110 percent of the appropriate stall speeds. (R 17)

Approach power was maintained until touchdown and the nosewheel was lowered to the runway as soon as possible after touchdown of the main landing gear. Immediately following nosewheel touchdown, the pilot released the control column to the copilot, placed his left hand on the nose steering wheel, rapidly moved the throttles into the reverse thrust range with his right hand, and depressed the brake pedals as far as possible. The smoothness and rapidity with which these operations could be accomplished greatly affected the landing ground distance. No tires were blown during this evaluation although a few minor skids occurred at low speed and could be felt by the pilot. No attempt was made to relax brake pedal pressure when the skids occurred.

The landing data were recorded by a Fairchild flight analyzer operated by Fairchild Hiller personnel. The data were corrected to standard day, sea level, no wind conditions, and are presented in figures 38 and 39, appendix I. A comparison of Flight Manual landing distances and those obtained during this evaluation is shown in table V.

TABLE V
MAXIMUM PERFORMANCE LANDING COMPARISON
SEA LEVEL, STANDARD DAY, NO WIND
FORWARD cg (20.6-percent MAC) FULL FLAPS (60 deg)
HARD SURFACE RUNWAY

	C-123K FLIGHT TEST				C-123K FLIGHT MANUAL			
GROSS WEIGHT (lb)	APPROACH SPEED (KIAS)	TOUCHDOWN SPEED (KIAS)	GROUND DISTANCE (ft)	TOTAL DISTANCE (ft)	APPROACH SPEED (KIAS)	TOUCHDOWN SPEED (KIAS)	GROUND DISTANCE (ft)	TOTAL DISTANCE (ft)
MAXIMUM BRAKING AND REVERSE THRUST								
58,700	91	83	950	1,770	90[2]	82[2]	1,140[2]	1,760[2]
43,950[1]	85	79	750	1,580	78	72	810	1,350
MAXIMUM BRAKING ONLY								
59,200	91	83	1,330	2,310	90	82	1,580	2,200
46,400	81	76	970	2,150	80	74	1,240	1,860

NOTE: 1. This condition flown with recip. engines at idle power during approach. Approach speed and touchdown speed based on idle power stall speed.

2. These same data are also presented in the C-123B Flight Manual.

For the landing approaches and landings flown with approximately zero reciprocating engine thrust, the flight test ground roll distances were 190 to 270 feet shorter than those shown in the C-123K and C-123B Flight Manuals. The air distances were as much as 360 feet longer than shown in the Flight Manuals.

A great deal of difficulty was encountered in obtaining landing air distance data. Poor weather and unfavorable wind conditions prevailed for the duration of this evaluation and since it was unlikely that these conditions would change in the near future, landing performance tests were conducted with wind conditions which would otherwise be unsatisfactory for test purposes. Although wind speed components along the runway at ground level were less than 6 knots in all cases, a strong wind shear was present at a height of approximately 50 to 75 feet. The presence of this wind shear made it extremely difficult to maintain the desired approach conditions and in addition made the accuracy of calculated wind velocities at 50 feet questionable. These conditions resulted in scatter in the landing air distances and thus the total distance data as presented in figures 38 and 39, appendix I. However, the data fairings should be representative of the actual performance which can be expected.

Plans to conduct landing tests from a sod field were cancelled because extensive snow and rain rendered all available fields in the area unusable.

STABILITY AND CONTROL

In general, the C-123K exhibited the same flying qualities as those of the C-123B (reference 9). The C-123B stability and control evaluation declared the C-123B directional stability to be unsatisfactory, the Dutch roll mode being so lightly damped as to possibly cause airsickness among troops or other passengers.

Unsatisfactory directional stability was also observed in the C-123K. The Dutch roll mode was characterized by low frequency oscillations which were very lightly damped, with the frequency and damping at a minimum at low airspeeds with full flap extension. Heading excursions of ±10 degrees were noted in all configurations in light to moderate turbulence. These heading excursions made precise heading control impossible.

A pilot would probably become quite frustrated during a precision radar approach if the ground controller directed a 1 or 2 degree heading change while the heading pointer oscillations totaled 20 degrees of arc.

Observed differences between the flying qualities of the C-123K and the C-123B were caused by jet engine operation in the C-123K. In flight, there was a slight noseup pitch change with jet power application and a slight nosedown pitch change with jet power reduction. Light elevator control forces were sufficient to counter these reactions. In addition, jet engine power changes introduced yawing moments which resulted in directional oscillations. These oscillations were annoying. No other differences from the C-123B were noted.

GROUND MINIMUM DIRECTIONAL CONTROL SPEED DETERMINATION

Ground minimum directional control speed tests were conducted at Olmsted Air Force Base, Pennsylvania. The tests were conducted at an aircraft gross weight of 45,000 pounds and a cg of 29 percent MAC. The left reciprocating engine was inoperative from brake release and all its cooling devices were set for the takeoff condition (cowl flaps TAKEOFF, oil cooler COLD). The left propeller was not feathered, however it did not windmill during the tests. The test technique employed consisted of advancing the power on the asymmetric operating engine as directional control permitted. The speed where sufficient control was available to hold the full asymmetric power condition was the ground minimum control speed. Because of the characteristics of the C-123 nosewheel steering system, the system was used only to prevent the nosewheel from castering. Due to the presence of an 8- to 14-knot wind directly down the runway, runs were conducted in both directions. With one reciprocating engine inoperative, full or nearly full aileron deflection was required to maintain a wings level attitude at approximately 50 to 60 KIAS. The dynamic case was not tested because, at the test site, the test would have been too hazardous. No quantitative data are presented due to high surface winds, lag errors in the photopanel airspeed system, and limited data. However, the experience gained during these tests and during the remainder of the test program led to the following conclusions:

1. With one jet engine inoperative and the other at military rated thrust and the reciprocating engines operating symmetrically, directional control could be maintained from brake release if nosewheel steering was used. If nosewheel steering was not used, a speed of approximatey 60 KIAS was required before achieving adequate directional control using full rudder, full nosedown elevator, and ailerons as required to maintain a wings level attitude.

2. With one reciprocating engine inoperative and the other at wet takeoff power with the jet engines operating symmetrically, directional control could be maintained above approximately

85 KIAS if nosewheel steering, full rudder, full nosedown elevator and ailerons as required to maintain a wings level attitude were used. In the case where nosewheel steering was not used for directional control, the ground minimum control speed was faster than the highest takeoff speed listed in the Flight Manual.

Based on the results of these tests and the above conclusions, the takeoff should be aborted if a reciprocating engine is lost prior to lift-off. In order to assure the immediate availability of nosewheel steering in the event of an engine failure, the pilot should keep his hand on the nose steering wheel until just prior to reaching rotation airspeed. (R 18, R 19)

AIR MINIMUM DIRECTIONAL CONTROL SPEED DETERMINATION

Air minimum control speed tests were accomplished with the left reciprocating engine inoperative. Various combinations of power on the right reciprocating engine and both jet engines were used to vary the asymmetric thrust moment. Tests were conducted in the cruise configuration (gear and flaps UP) and the takeoff configuration (gear DOWN, flaps TAKEOFF). Bank angle was maintained at zero and 5 degrees by reference to the horizon and reference lines drawn on the pilot's windshield.

Full rudder deflection was available at all airspeeds tested with less than approximately 200 pounds of rudder pedal force. This maximum rudder force is slightly greater than the 180-pound limit specified by MIL-F-8785(ASG), but the rudder forces were not high enough to prohibit the use of full rudder deflection when defining the air minimum control speed and therefore were considered acceptable for the correction of an emergency situation in operational use.

The test technique employed consisted of setting the asymmetric power condition at an airspeed known to be above the air minimum control speed and applying full right rudder and the desired bank angle. Under these conditions, the aircraft nose was turning to the right. As airspeed was reduced the turn rate decreased until it finally stopped. The airplane was stabilized at that airspeed and the desired parameters were recorded. The test was repeated for various asymmetric moment conditions.

The rudder moments for zero and 5 degrees of bank versus the thrust moment available for both the inoperative engine feathered and windmilling cases are presented in figure 40, appendix I. The air minimum control speeds are the intersections of the rudder moment and thrust available curves. The minimum control speeds represent indicated airspeeds which would have been obtained for a pitot-static system with no sideslip errors (see Data Analysis Methods, appendix I).

The minimum control speed was very sensitive to bank angle; a small increase in bank angle away from the inoperative reciprocating engine reduced the minimum control speed significantly. The minimum directional control speeds with one jet engine inoperative and the remaining jet engine at military rated thrust (symmetric reciprocating engine power) were below the zero thrust stall speeds for the gross weights tested. Minimum control speeds were not affected by symmetric changes in reciprocating engine power or jet engine thrust. Reducing the jet engine thrust on the side opposite the failed reciprocating engine aided directional control significantly. A comparison of the air minimum directional control speeds obtained during this evaluation and those presented in the Flight Manual is shown in table VI. The air minimum control speeds obtained during this evaluation were approximately 8 knots higher than the Flight Manual speeds with the wings level and approximately 7 knots lower with 5 degrees of bank. It should be noted that the Flight Manual air minimum control speeds for the 5 degrees of bank condition are presented for a gross weight of 54,000 pounds. The air minimum control speeds obtained during this evaluation were for a gross weight of 46,000 pounds. Correcting the speeds to a common weight would result in an even larger difference than the 7 knots stated above. The Flight Manual should be changed to reflect the air minimum directional control speeds contained in this report. (R 20)

STALLS

Tests were conducted to determine the zero thrust and throttles closed stall speeds and stall characteristics of the C-123K aircraft. The aircraft was stalled in the cruise, TAKEOFF (20-degrees), LAND (45-degrees), and FULL (60-degrees) flap configurations and with the landing gear in both the UP and DOWN positions.

In the cruise configuration, aerodynamic stall warning was characterized by a yawing oscillation 2 to 4 knots prior to stall. Aerodynamic warning was seldom noted prior to stall if the flaps were extended. Stalls were characterized by an initial mild "g break" (defined as the stall) followed by moderate buffet, and then a sharp pitch down approximately 5 knots below the initial break. On one occasion with full flaps extended and approximately

TABLE VI

AIR MINIMUM DIRECTIONAL CONTROL SPEED COMPARISON

SEA LEVEL STANDARD DAY CONDITIONS
LEFT RECIPROCATING ENGINE INOPERATIVE
LEFT JET ENGINE INOPERATIVE
TAKEOFF CONFIGURATION

			C-123K FLIGHT MANUAL GROSS WEIGHT - 54,000 lb		C-123K FLIGHT TEST GROSS WEIGHT - 46,000 lb	
RIGHT RECIPROCATING ENGINE POWER	RIGHT JET ENGINE THRUST	ANGLE OF BANK (deg)	V_{mc} (KIAS) PROPELLER FEATHERED	V_{mc} (KIAS) PROPELLER WINDMILLING	V_{mc} (KIAS) PROPELLER FEATHERED[1]	V_{mc} (KIAS) PROPELLER WINDMILLING[2]
MAXIMUM WET (2500 BHP)	MILITARY RATED THRUST	0	-	-	137	148
		5	-	-	106	117
MAXIMUM WET (2500 BHP)	INOP	0	100	109	108	116
		5	92	99	84	92
MAXIMUM DRY (2300 BHP)	INOP	0	97	106	105	113
		5	90	97	82	89
METO (1900 BHP)	INOP	0	91	100	98	106
		5	84	92	77	84

NOTES: 1. All cooling devices closed.

2. Cowl flaps TAKEOFF - oil cooler COLD.

zero thrust, the aircraft was held in the stall after the initial break. Under these conditions, the second break was accompanied by an abrupt right roll. Recovery was accomplished by relaxing control column back pressure to regain airspeed and then neutralizing the controls. No abnormal characteristics were noted during stall recovery.

A limited number of power-on stalls were conducted in conjunction with the Monitair Angle of Attack/Stall Warning System Evaluation. Stalls were conducted at power settings up to 1100 BHP. Recovery from power-on stalls was initiated immediately following the initial g break. No undesirable stall or recovery characteristics were noted as long as this technique was used.

Stall summary plots for the zero thrust and throttles closed conditions are presented in figures 12 and 13, appendix IV, respectively. It is significant that the idle power stall speed was approximately 5 knots higher than the zero thrust stall speed in the cruise configuration, and approximately 7 knots higher with the flaps fully extended. The power-off stall speeds presented in the Flight Manual were actually zero thrust stall speeds. An idle power stall speed chart should be added to the Flight Manual and the power off chart should be relabeled Zero Thrust Stall Speeds. (R *21)

The control column shaker provided adequate artificial stall warning in all configurations and conditions tested. The stall warning system is further discussed in appendix IV.

AIRSPEED CALIBRATION

Airspeed calibration tests were conducted to determine the position error of the production pitot-static system. Data were obtained by flying in formation with the Wright-Patterson Air Force Base T-37 calibrated pacer. Photopanels installed in both the test aircraft and the pacer aircraft were used to record instrument readings.

The C-123K production pitot-static system consisted of separate pilot's and copilot's pitot probes and one flush static source on each side of the fuselage. The static sources were manifolded and the manifold was common to the pilot's and copilot's instruments. Locations of the pressure sources are shown in figure 41, appendix I. As can be seen from this figure, test results differed significantly from the airspeed position error correction data presented in the Flight Manual. The Flight Manual should be changed to reflect the position correction determined during this evaluation. Test results are shown in figures 41 and 42, appendix I. (R 22)

During the test program it was noted that sideslip produced errors in indicated airspeed. On one occasion, the aircraft was stabilized in a constant heading sideslip (airplane nose right) with a 5-degree left bank. In this condition, the pilot's indicated airspeed was 102 knots and the copilot's was 90 knots. In a 5-degree right bank with constant heading sideslip (airplane nose left) the indicated airspeeds reversed, with the copilot's indicated airspeed being 12 knots higher than the pilot's. Since the pilot's and copilot's airspeed indicators were connected to a common static pressure system, it was concluded that this difference in indicated airspeed was caused by a difference between the pilot's and copilot's system total pressures. Since the Flight Manual recommends the wing low method for compensating for crosswind effects during approach and landing, the pitot-static system should be modified to correct errors in indicated airspeeds due to sideslip. (R *23)

GROUND STATIC THRUST CALIBRATION

Ground static thrust tests were performed to determine the installed static thrust of the J85-GE-17 engines, and to obtain a tailpipe calibration for use in computing the inflight gross thrust.

The photopanel was used to record engine parameters. Static thrust and local atmospheric conditions were measured by the Wright-Patterson Air Force Base horizontal thrust measuring facility.

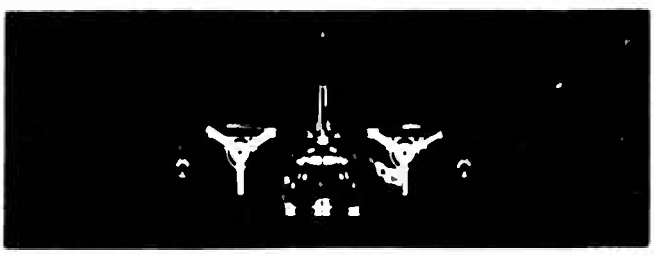
The jet engines were operated at various preselected power settings from idle to military rated thrust with both engines at the same power setting. Thrust stand and engine parameters were recorded after a 3-minute stabilization period at each test condition.

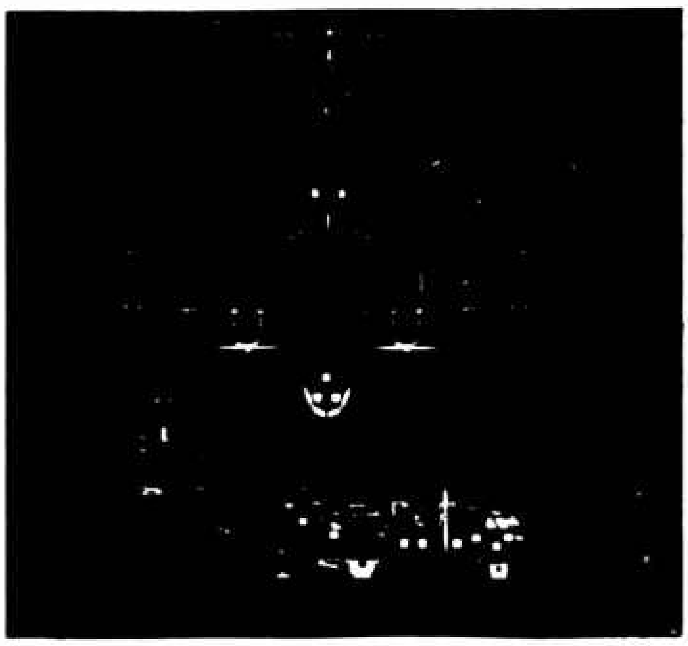
The average installed military rated thrust for these two engines, corrected to a sea level, standard day was 2,800 pounds. Results of the static thrust calibration are shown in figures 43 and 44, appendix I.

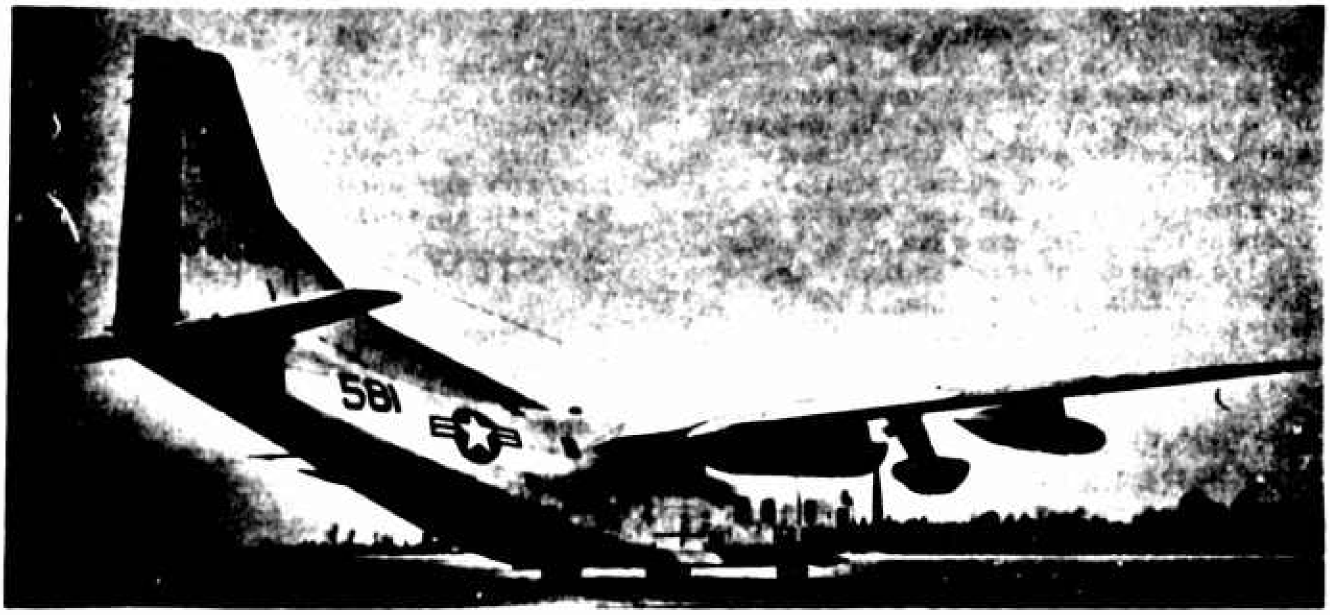
SYSTEM MALFUNCTIONS

Two jet engine shutter door actuator failures occurred during the test program. The cause of these malfunctions was not determined. In addition, one jet engine (S/N GE-E-247001) was replaced during the test program due to foreign object damage. The characteristics of the damage sustained indicated that it was probably caused by ingestion of a screw or bolt.

Stall tests were conducted with the jet engines operating at both idle and military rated thrust. No adverse jet engine effects due to low speeds or high angles of attack were noted.







CONCLUSIONS AND RECOMMENDATIONS

GENERAL

C-123K test results indicated a substantial improvement in takeoff and climb performance over that of the C-123B aircraft. Landing ground distances obtained during this evaluation were slightly shorter and total distances were slightly longer than those presented in both the C-123B and C-123K Flight Manuals. Addition of the jet engines resulted in a drag increase corresponding to a loss of approximately 7 KIAS for the same reciprocating engine power setting at an aircraft gross weight of 50,000 pounds, sea level standard day conditions, and at best cruise speed. In general, stability and control characteristics were similar to those of the C-123B aircraft. The unsatisfactory lateral-directional characteristics made precise heading control impossible under turbulent conditions.

1. The Flight Manual specific range values should be changed to reflect the drag levels shown in this report and the fuel consumption data shown in the Flight Manual (page 11).

Changes to the cockpit consisted mainly of the addition of controls and instruments for the jet engines, the antiskid system, and the Monitair angle of attack/stall warning system. Three prominent cockpit deficiencies were noted: the REPLENISH PROP OIL panel was moved to the pilot's instrument panel which resulted in the propeller oil warning lights being partially hidden behind the control column; there was no master fire warning light installed in the test aircraft; and the test aircraft jet engine oil pressure indicators had a range of only 0 to 100 psi when an oil pressure of 185 psi within 5 minutes after starting was allowable.

2. The REPLENISH PROP OIL panel should be moved to a location where the pilot will have an unobstructed view of the warning lights (page 3).

3. All C-123K aircraft should be equipped with a master fire warning light (page 3).

4. All C-123K aircraft should be equipped with jet engine oil pressure indicators having a 0-200 psi range (page 3).

The jet engine start switches were unsatisfactory due to detents which were not sufficiently pronounced and because of the presence of several unused switch positions.

5. A simpler jet engine start switch and automatic start sequencing should be incorporated (page 4).

6. In the event that automatic start sequencing is not incorporated, the jet engine starting procedure presented in the Flight Manual should be changed to allow selection of the FUEL TO 38% RPM position directly from the SHUTTER position. In addition the procedure should specify that the start switch should remain in the FUEL TO 38% RPM position until 35- to 38-percent jet engine RPM is reached (page 4).

Serious electrical power failures were possible during jet engine starts with electrical and jet engine starting systems as installed in the test aircraft. Loss of all aircraft generators was possible through inattention during jet engine starts. Aircraft electrical power was inadequate to start both jet engines simultaneously, or to start one jet engine with the propeller and jet engine deicing systems operating.

*7.[3] The electrical system load capability should be increased and reverse current protection during jet engine starting should be incorporated (pages 4 and 5).

The location of the jet engine throttle switches on the center pedestal aft of the throttle quadrant was slightly inconvenient. Jet engine thrust regulation at other than idle or full power was difficult due to rapid throttle actuator operation. The jet throttle controls and their location were acceptable since the engines were normally operated at idle or full power and were used only for thrust augmentation. Jet engine acceleration characteristics at high altitudes were undesirable but acceptable based on the aircraft design concept of the jet engines being used primarily as auxiliary power for takeoff and climb. Engine acceleration characteristics were normal when engine speed was maintained above 70-percent rpm at altitudes above 14,000 feet.

8. Until a study is completed to determine a practical high altitude jet engine idle speed, a NOTE should be placed in the Flight Manual to inform the pilot of the idle speed requirements and engine acceleration characteristics at high altitude (page 6).

The jet engine fuel supply system was unsatisfactory. The jet engine boost pumps cavitated

[3] Those recommendations preceded by an asterisk are considered to be safety of flight items.

during initial climb following a maximum performance takeoff with as much as 2,000 to 2,200 pounds of fuel in each nacelle tank. Fuel transfer from the pylon tanks to the nacelle tanks could not be accomplished with the jet engines operating.

9. The nacelle tank/boost pump configuration should be changed so that maximum performance takeoffs can be performed without danger of jet engine fuel starvation (page 5).

***10.** Until recommendation 9 is adopted, the Flight Manual should warn that jet engine flameouts have occured during maximum performance takeoffs and climbs with less than 2,200 pounds of fuel in each nacelle tank (page 5).

11. The fuel system should be changed to allow fuel transfer during jet engine operation (page 5).

Electrical power for jet pod anti-icing was supplied by the aircraft 28-volt dc flight emergency bus. Operation of the anti-icing system under emergency conditions during which reciprocating engine generator power is unavailable would result in premature loss of battery power.

12. Electrical power for the jet engine pod anti-icing system should be supplied from the aircraft primary dc bus (page 6).

Takeoff performance of the C-123K was substantially improved over that of the C-123B. Use of the jet engines for takeoff resulted in about a 4-knot increase in minimum nosewheel lift-off speed. The nosedown pitching moment about the main landing gear due to the jet engine thrust coupled with a forward cg condition resulted in inadequate elevator power to rotate the aircraft to the takeoff attitude at the Flight Manual recommended takeoff speed. Speed control during initial climb was maintained by reference to the stall margin indicator.

***13.** Maximum performance takeoff charts for the jet engines operating for both forward and aft cg conditions should be added to the Flight Manual. The takeoff performance for the aft cg condition should be based on the current Flight Manual takeoff speeds increased by 4 knots to compensate for the nosedown pitching moment about the main landing gear due to the jet engine thrust. Since the C-123B flight test report, reference 2, indicated that a forward cg condition resulted in a 3- to 5-knot increase in nosewheel lift-off speed, the forward cg takeoff performance should be based on the current Flight Manual takeoff speed increased by 8 knots to compensate for the nosedown pitching moment due to the jet engine thrust coupled with a forward cg condition. Both charts should reflect the performance levels contained in this report (page 8).

14. A stall margin indication of 1.1 V_s should be maintained during initial climb following a maximum performance takeoff (page 8).

The optimum climb speed for all conditions tested occurred at an airspeed less than the Flight Manual recommended speed of 130 KIAS.

15. Due to the improved engine cooling, the simplicity provided by maintaining a constant airspeed throughout the climb, and the insignificant climb performance degradation, the Flight Manual recommended climb speed (130 KIAS) should be used for climbs with all engines operating (page 9).

Modification of the C-123B aircraft to the C-123K configuration resulted in an incremental drag coefficient increase of 0.0055. Recommended cruise speeds were as much as 7 percent (10 knots) slower than those presented in the Flight Manual. Specific range (NAMPP) at the respective recommended cruise speeds was as much as 5 percent lower than that presented in the Flight Manual for the same conditions.

A constant stall margin indication of 1.25 V_s with flaps up and 1.3 V_s with flaps deflected 20 or 45 degrees resulted in satisfactory approach speeds for normal landings. Maximum performance was obtained by flying the approach with full flaps at a reciprocating engine manifold pressure of 18 to 20 inches of mercury and a stall margin indication of 1.2 V_s or 120 percent of the zero thrust stall speed determined during this evaluation. With the jets inoperative, the approach and flare techniques and handling characteristics were the same as those of the C-123B.

16. The Flight Manual should be changed to recommend approach speeds corresponding to stall margin indications of 1.25 V_s for flaps up and 1.3 V_s for flaps down 20 or 45 degrees (page 12).

17. Considering the effect of approach speed and engine power condition on aircraft handling qualities and performance, maximum performance approaches should be flown with full flaps, a reciprocating engine manifold pressure of 18 to 20 inches of mercury and either a stall margin indication of 1.2 V_s or 120 percent of the zero thrust stall speed determined during this evaluation (page 13).

A slight noseup pitch change with jet power application and a slight nosedown pitch change with jet power reduction was noted in flight. Light elevator forces were sufficient to counteract these pitching moments. Jet engine power changes introduced yawing moments which resulted in directional oscillations. These oscillations were annoying.

With one jet engine inoperative and the other at military rated thrust and the reciprocating engines operating symmetrically, directional control on the ground could be maintained from brake release when nosewheel steering was used. If nosewheel steering was not used, a speed of approximately 60 KIAS was required before achieving adequate directional control using full rudder, full nosedown elevator, and ailerons as required to maintain a wings level attitude. With one reciprocating engine inoperative and the other at wet takeoff power with the jet engines operating symmetrically, directional control could be maintained above approximately 85 KIAS if nosewheel steering, full rudder, full nosedown elevator, and ailerons as required to maintain a wings level attitude were used. With one reciprocating engine inoperative, full or nearly full aileron deflection was required to maintain a wings level attitude at approximately 50 to 60 KIAS. In the case in which nosewheel steering was not used for directional control, the ground minimum control speed was faster than the highest takeoff speed listed in the Flight Manual.

***18.** Based on the results of these tests and the above conclusions, the takeoff should be aborted if a reciprocating engine is lost prior to lift-off (page 16).

***19.** In order to assure the immediate availability of nosewheel steering in the event of an engine failure, the pilot should keep his hand on the nose steering wheel until just before reaching rotation airspeed (page 16).

The air minimum directional control speeds with one jet engine inoperative and the remaining jet engine at military rated thrust (symmetric reciprocating engine power) were below the zero thrust stall speeds for the gross weights tested. Minimum control speeds were not affected by symmetric changes in jet thrust. Reducing the jet engine thrust on the side opposite the failed reciprocating engine aided directional control significantly. The air minimum directional control speeds obtained during this evaluation were approximately 8 knots higher than the Flight Manual speeds with the wings level and more than 7 knots lower with 5 degrees of bank.

20. The Flight Manual should be changed to reflect the air minimum directional control speeds contained in this report (page 17).

The stall was generally mild if recovery was accomplished immediately by relaxing force on the control column. Idle power stall speeds were approximately 5 knots higher than the zero thrust stall speed in the cruise configuration, and approximately 7 knots higher with the flaps fully extended. The power-off stall speeds presented in the Flight Manual were actually zero thrust stall speeds.

***21.** An idle power stall speed chart should be added to the Flight Manual and the power off chart should be relabeled Zero Thrust Stall Speeds (page 18).

The airspeed position error correction determined during this evaluation differed significantly from that presented in the Flight Manual. Sideslip produced erroneous airspeed indications.

22. The Flight Manual should be changed to reflect the position error correction obtained during this evaluation (page 18).

***23.** The production pitot-static system should be modified to correct errors in indicated airspeeds due to sideslip (page 19).

MONITAIR ANGLE OF ATTACK/ STALL WARNING SYSTEM

The Monitair angle of attack/ stall warning system installed in a C-123K provided adequate artificial stall warning in all configurations and conditions tested. In addition, speed control during initial climbs and landing approaches was more precise than was possible by use of the airspeed indicator alone. Stall speeds and stall margin indication were unaffected by landing gear position. No system malfunctions were noted during this evaluation; however, the limited amount of flying time allowed was not adequate to judge the reliability of the Monitair system.

Although the aircraft was not flown at night, the instrument lighting was observed after dark and the lighting was judged to be uniform and satisfactory. No electromagnetic interference between the Monitair system and other aircraft electrical systems was noted.

The stall margin indicator was mounted above the pilot's glare shield and was unreadable from the copilot's position.

24. A second indicator should be installed in a similar location above the copilot's glare shield (page 98).

Electrical power for the Monitair system was supplied from the primary dc bus and all artificial stall warning would be lost in the event of complete generator failure.

25. Electrical power for the Monitair system should be supplied from the aircraft flight emergency bus (page 99).

Although the power compensation switches within the throttle quadrant provided a constant 0.06 bias to the stall margin indication and artificial stall warning functions, the resulting error was less than 2 percent and was satisfactory.

Errors in stall margin indication at power settings above that for zero thrust were conservative and satisfactory.

The initial climb airspeed, using the airspeed indicator for speed control, was difficult to maintain due to lack of a suitable reference for use in making small corrections to the aircraft pitch attitude. The proper stall margin indication was easier to maintain than an indicated airspeed.

26. The stall margin indicator should be used as the primary instrument for speed control during initial climb (reference recommendation 14) (page 99).

Recommended continuous climb and best cruise speeds for a C-123K are not at constant angles of attack and therefore a constant stall margin indication could not be used for proper speed control during these conditions.

Speed control during landing approaches using the stall margin indicator as the primary reference was easier and more precise than was possible by reference to the airspeed indicator alone.

27. The stall margin indicator should be used as the primary speed control instrument during visual approaches (page 103).

Stall margin indicator needle fluctuations caused by turbulence were slightly greater than those of the production C-123K airspeed indicator but were acceptable.

APPENDIX I

DATA ANALYSIS METHODS AND TEST DATA

GROSS WEIGHT DETERMINATION

The in-flight gross weight was obtained by subtracting the total fuel used at the point desired from the preflight weight. The incremental fuel used for the turbojet and reciprocating engines was obtained from fuel counters. These values of fuel used (in gallons) were multiplied by the average fuel density over the incremental time period considered. The summation of the fuel used increments gave the fuel used from engine start to the point in time being considered.

FUEL FLOW DETERMINATION

Fuel flow was measured by Revere flowmeters and Stepper Motor timers. Fuel temperature was measured at each flowmeter. Fuel flow was computed for each of the operating engines and then totaled by the following equation:

$$W_{f_{total}} = \Sigma[(W_{f_i} + \Delta W_{f_{ic}})(FD)]$$

where:

W_{f_i} = indicated fuel flow (gph)

$\Delta W_{f_{ic}}$ = flowmeter instrument correction (gph)

FD = fuel density at the test point (lb/gal)

Fuel flow corresponding to power for standard conditions was obtained by using the fuel flow computed above and adding to it the differential fuel flow due to the difference between test and standard day power.

Metering Suction Differential Pressure (MSDP) was measured and compared to the MSDP-fuel flow limits and flow bench check that was conducted prior to the test program. Inspection of these data revealed that both carburetor calibrations had shifted and the carburetors were operating with too rich a fuel mixture. The carburetors were removed and recalibrated at the Norfolk Naval Air Station, Virginia, prior to flight K-41. This shift in carburetor calibration was primarily due to improper setting of the automatic mixture control unit. MSDP was measured throughout the remainder of the test program and compared to the carburetor manufacturer's MSDP-fuel flow limits and the second flow bench check. These data as presented in figures 50 through 53 indicate that the carburetors maintained their calibration throughout the remainder of the test program.

Plots of fuel flow versus BHP were made using data obtained before and after the second flow bench check. Fuel flow data obtained prior to flight K-41 was corrected by entering these plots with the test day BHP and determining the differential fuel flow to be subtracted from the test fuel flow.

PROPELLER EFFICIENCY DETERMINATION

Test day propeller efficiency, assuming no compressibility losses, was determined from the propeller efficiency chart (figure 1). The airplane Mach number at each test point was compared with the maximum airplane Mach number for no compressibility losses as tabulated in figure 1. Compressibility corrections, if required, were determined from figure 3.

Propeller efficiency (η_p) is a function of power coefficient (C_P) and advance ratio (J). Power coefficient and advance ratio are functions of BHP, rpm, density, and true airspeed. Assuming no Mach effects it then follows that for every combination of BHP, rpm, density, and true airspeed there is only one propeller efficiency and thus only one thrust horsepower (THP = BHP x η_p). By reversing this process it can be said that for each combination of THP, density, rpm, and true airspeed there is only one propeller efficiency and thus only one brake horsepower. Thus, a propeller efficiency chart could be constructed in which η_p would be a function of a thrust horsepower coefficient ($C_{P_{THP}}$) and advance ratio. Once the standard day thrust horsepower required and true airspeed were known, such a chart could be used to determine standard day propeller efficiency and thus eliminate the lengthy iteration process which would otherwise be required. A standard day propeller efficiency chart (figure 2) was constructed for the 43E60 propeller with 6917B-14 blades used on the C-123K.

Standard day propeller efficiency assuming no compressibility losses was determined from figure 2. In the cases where compressibility corrections were required, the corrections determined in the calculation of test day propeller efficiency were used.

JET ENGINE THRUST DETERMINATION

The jet engine in-flight gross thrust was computed from the results of static thrust calibration tests conducted on the Wright-Patterson Air Force Base static thrust stand (figure 44). Jet engine net thrust was calculated by use of figures 44 and 45 and the following equation:

$$F_n = F_g - F_e$$

where:

$$F_e = 0.05245\ V_t\ W_a$$

TAKEOFF PERFORMANCE

Phototheodolite and photo-recorder data were corrected to standard day, sea level conditions by use of the following equations:

$$\frac{S_{g_s}}{S_{g_t}} = \left[\frac{W_s}{W_t}\right]^{(2.3 + 0.26\ KP)} \left[\frac{\sigma_s}{\sigma_t}\right]^{-(1 + 0.65\ KP)} \left[\frac{F_{n_s}}{F_{n_t}}\right]^{-1.3\ KJ} \left[\frac{THP_{r_s}}{THP_{r_t}}\right]^{-0.91\ KP} \left[\frac{N_{r_s}}{N_{r_t}}\right]^{-0.65\ KP}$$

$$\frac{S_{a_s}}{S_{a_t}} = \left[\frac{W_s}{W_t}\right]^{(2.3 + 0.32\ KP)} \left[\frac{\sigma_s}{\sigma_t}\right]^{-(0.7 + 0.8\ KP)} \left[\frac{F_{n_s}}{F_{n_t}}\right]^{-1.6\ KJ} \left[\frac{THP_{r_s}}{THP_{r_t}}\right]^{-1.12\ KP} \left[\frac{N_{r_s}}{N_{r_t}}\right]^{-0.8\ KP}$$

For this section the following nomenclature applies:

W = gross weight (lb)

σ = density ratio

F_n = net jet thrust (lb)

THP_R = reciprocating engine thrust horsepower

N_r = reciprocating engine rotational speed

S_g = ground roll (ft)

S_a = air distance (ft)

The subscripts s and t denote standard and test conditions, respectively.

KP - ratio of propeller thrust to total thrust,

$$KP = \frac{(THP_R)(550/0.75V_{t_{s_{LO}}} \times 1.6889)}{F_n + THP_R\ (550/0.75V_{t_{s_{LO}}} \times 1.6889)}$$

KJ - the ratio of jet thrust to total thrust,

$$KJ = \frac{F_n}{F_n + THP_R\ (550/0.75V_{t_{s_{LO}}} \times 1.6889)}$$

The above corrections were derived from equations presented in reference 5.

Wind corrections to the ground roll were made with the following equation:

$$S_{g_t} = S_{g_{t_W}} \left[\frac{V_{g_{LO}} \begin{smallmatrix} + V_{headwind} \\ - V_{tailwind} \end{smallmatrix}}{V_{g_{LO}}} \right]^{1.85}$$

Where: wind velocity was measured at approximately 6 feet.

In addition to the computations noted, the true airspeed at lift-off and 50 feet altitude were calculated for sea level standard day conditions and a standard weight using the equations:

$$V_{t_{LO}} = V_{t_{t_{LO}}} \sqrt{\frac{W_s}{W_t}\ \sigma_t},$$

where:

$$V_{t_{t_{LO}}} = V_{g_{LO}} \begin{smallmatrix} + V_{headwind} \\ - V_{tailwind} \end{smallmatrix} \quad \text{and}$$

$$V_{t_{s_{50}}} = V_{t_{t_{50}}} \sqrt{\frac{W_s}{W_t}\ \sigma_t},$$

where:

$$V_{t_{t_{50}}} = V_{g_{50}} \begin{smallmatrix} + 1.35\ V_{headwind} \\ - 1.35\ V_{tailwind} \end{smallmatrix}$$

These values are required to determine sea level standard day reciprocating engine thrust horsepower. This standard day thrust horsepower was based on 2,500 BHP with the ADI on and 2,300 BHP with the ADI off. In calculating the standard day propeller efficiency, the power coefficient was based on 2,500 BHP with the ADI on and 2,300 BHP with the ADI off, and the propeller advance ratio was based on 0.75 $V_{t_{LO}}$. The jet engine power correction was based on 94 percent of a standard day static thrust of 2,800 pounds.

CLIMB PERFORMANCE

SAWTOOTH CLIMBS

The test day rate of climb for zero acceleration was determined from the rate of change of specific energy (E/W) based on tapeline altitude and test day true airspeed. The test day rate of climb was corrected to that which would be obtained on a standard day at the same equivalent airspeed by the expression:

$$R/C_t = \frac{\Delta(E/W)}{\Delta_t} \sqrt{T_{a_s}/T_{a_t}}$$

To determine the differential rate of climb due to temperature effects on turbojet power, test and standard day net thrust were calculated and the resulting test and standard day thrust horsepower determined. In the determination of standard day reciprocating engine power the following corrections were required:

1. Correction for carburetor air temperature variation at constant manifold pressure.

2. Correction for manifold pressure variation resulting from carburetor air temperature variation.

3. Manifold pressure correction due to temperature variation for full throttle position.

At altitudes below the critical altitude (approximately 7,000 feet in low blower and 16,000 feet in high blower for a standard day), it was possible to obtain METO power at less than full throttle. Constant brake horsepower was maintained and thus the required manifold pressure decreased during that part of the climb due to decreased exhaust back pressure. Standard day manifold pressure was determined as follows:

$$MAP_s = MAP_t \,[1 + C\,(\Delta T)]$$

where:

$\Delta T = Ta_s - Ta_t$

C = a constant determined from chart 2.32, reference 6.

At altitudes above the critical altitude the throttle was fully open. Consequently, any increase in altitude resulted in a decrease in manifold pressure and a corresponding decrease in horsepower. The equation used to determine standard day manifold pressure for test points above the critical altitude was:

$$MAP_s = MAP_t \,[1 - C\,(\Delta T)]$$

where:

$\Delta T = Ta_s - Ta_t$

C = a constant determined from chart 2.32, reference 6.

Standard day BHP was then calculated using the following equation:

$$BHP_s = BHP_t \left[\left[\left(\frac{CAT_t}{CAT_s} \right)^{1/2} + \left(\frac{MAP_s}{MAP_t} \right) \right] - 1 \right]$$

Where: CAT is in deg K.

Test and standard day reciprocating engine thrust horsepower were determined by multiplying by test and standard day brake horsepower by the appropriate propeller efficiency.

The differential rate of climb due to temperature effects on both turbojet and reciprocating engine power was then calculated by the following equation:

$$\Delta R/C_1 = \frac{33{,}000}{W_t} \left(ETHP_s - ETHP_t \sqrt{Ta_s/Ta_t} \right)$$

where $ETHP = THP_{jet} + THP_{recip}$

Weight corrections for the sawtooth climbs were computed from the following equation:

$$\Delta R/C_2 = (R/C_t + \Delta R/C_1) \left[\frac{W_t - W_s}{W_s} \right]$$

The induced drag corrections were computed from the following equation:

$$\Delta R/C_3 = \frac{25.38 \sqrt{T_{a_s}}}{P_{a_s} \ b^2 eM} \left[\frac{W_t^{\,2} - W_s^{\,2}}{W_s} \right]$$

In computing the standard rate of climb, the following equation was used:

$$R/C_s = (R/C_t + \Delta R/C_1 + \Delta R/C_2 + \Delta R/C_3)$$

The sawtooth climb points are presented for zero acceleration.

CONTINUOUS CLIMBS

The test day rate of climb for the continuous climbs was determined by the procedure explained in the Sawtooth Climbs section of this appendix.

The gross weight during the climb was adjusted by iteration to the gross weight that would have resulted from a climb on a standard day with standard fuel flow.

Temperature, weight, and induced drag corrections to the rate of climb for check climbs were computed from the equations presented in the Sawtooth Climb section.

The total expression for standard day rate of climb at zero acceleration was thus:

$$R/C_{s_{a=o}} = (R/C_t + \Delta R/C_1 + \Delta R/C_2 + \Delta R/C_3)$$

Continuous climb data were then corrected for acceleration by equation 5.503, reference 6, considering zero variation in calibrated airspeed with altitude.

$$R/C = \frac{R/C_{s_{a=o}}}{A_f}$$

where:

$$A_f = 1 + \frac{(1.6889)^2 \ V_t}{g} \ \frac{dV_t}{dH}$$

LEVEL FLIGHT PERFORMANCE

Level flight performance data were obtained from the flight notes and from the photorecorder. The test data were corrected for temperature, weight, and rates of climb or descent. All cruise configuration speed-power tests were flown with the oil cooler doors full open (COLD) and the cowl flaps in the faired position. One speed-power was flown in the power approach configuration. For that test, the oil cooler doors were full open (COLD) and the cowl flaps were set in the TAKEOFF position.

STANDARD DAY SHAFT HORSEPOWER REQUIRED

Test day level flight brake horsepower was computed from torquemeter and tachometer readings by the expression:

$$BHP = 0.000632 \ (Q) \ (N_r)$$

Test day reciprocating engine thrust horsepower required was then computed by multiplying BHP by the test day propeller efficiency.

Jet engine thrust was computed and converted to thrust horsepower as follows:

$$THP_{jet} = F_{n_t} (V_{t_t})/325.655$$

An energy correction for variations in airspeed and altitude during the test run was determined from:

$$\Delta THP_E = \left(\frac{\Delta E/W}{\Delta_t}\right) (W_t/550)$$

Test day equivalent horsepower required was then computed from the following equation:

$$ETHP_{t_{total}} = THP_{jet_t} + THP_{recip_t} + \Delta THP_E$$

Induced drag changes caused by weight corrections were determined by an equation given in reference 7:

$$\Delta THP_{wt} = 0.2880 \ (W_s^2 - W_t^2)/eb^2 \sigma_s V_{t_s}$$

The test day thrust horsepower required was corrected to standard day temperature and standard day equivalent thrust horsepower was determined.

$$ETHP_{s_{total}} = (ETHP_{t_{total}}) (\sqrt{T_{a_s}/T_{a_t}}) + \Delta THP_{wt}$$

The difference between test and standard day thrust horsepower due to the jet thrust was added to or subtracted from the reciprocating engine power. Thus standard day BHP required was determined as follows:

$$BHP_s = (ETHP_{s_{total}} - THP_{s_{jet}})/\eta_{p_s}$$

GENERALIZED POWER REQUIRED

All level flight power required data were generalized to the power parameter, $ETHP_{iw}$, and speed parameter, V_{iw}, derived from section 4.6, reference 6. These parameters are shown below:

$$ETHP_{iw} = ETHP_{t_{total}} \sqrt{\sigma_t} \ (W_{iw}/W_t)^{1.5}$$

$$V_{iw} = V_{t_t} \sqrt{\sigma_t} \ (W_{iw}/W_t)^{0.5}$$

Where: W_{iw} = 50,000 pounds.

LIFT AND DRAG COEFFICIENTS

The lift and drag coefficients were calculated from test day data as follows:

$$C_L = 0.2410 \ W_t/\sigma_t \ V_{t_t}^2$$

$$C_D = 78.47 \ (ETHP_t)/\sigma_t \ V_{t_t}^3$$

SPECIFIC RANGE

NAMPP was calculated using standard day true airspeed and total fuel flow.

$$NAMPP = V_{t_s}/W_{f_s}$$

LANDINGS

Phototheodolite recorded data were corrected to sea level standard day no wind conditions using the methods outlined in reference 6. No attempt was made to correct for power, reverse thrust, or weight. The expressions used for data reduction were as follows:

$$S_{g_s} = S_{g_{t_w}} \sigma_t \left(\frac{V_{g_{t_{TD}}} + V_w}{V_{g_{t_{TD}}}}\right)^{1.85}$$

$$S_{a_s} = S_{a_{t_w}} + (t_{air} V_w 1.6889)$$

$$V_{t_{s_{TD}}} = (V_{g_{t_{TD}}} + V_w) \sqrt{\sigma_t}$$

$$V_{t_{s_{50}}} = (V_{g_{t_{50}}} + 1.35 V_w) \sqrt{\sigma_t}$$

where:

$+ V_w$ = headwind

$- V_w$ = tailwind

AIR MINIMUM DIRECTIONAL CONTROL SPEED DETERMINATION

Air minimum control speed data are presented as a function of thrust moment. In computing the thrust moment the following equation was used:

$$\text{Thrust moment} = 25.92 (F_{n_t}) + 4911 \, THP_{R_t}/V_{t_t}$$

Where: THP_{R_t} = test day reciprocating engine thrust horsepower.

Jet thrust and reciprocating engine thrust horsepower were computed using methods previously discussed.

The yawing moment produced by the fully deflected rudder was assumed to be the product of a constant area and moment arm times the dynamic pressure (q).

In the airspeed calibration discussion contained in this report, it is mentioned that sideslip produced erroneous indicated airspeeds. The effect on pilot's and copilot's indications was dependent on the direction of the sideslip. It was therefore impractical to present minimum control speed in terms of pilot's calibrated airspeed since the V_{mc} would be dependent on which engine was lost. The V_{mc} presented was therefore obtained by one of the following methods.

Either V_{mc} was assumed to be the average of the pilot's and copilot's calibrated airspeeds; or in the other cases, when the copilot's indicated airspeed was not recorded, V_{mc} was determined from the stall margin indication at that point and from figures 2 and 3, appendix IV.

In the cases where the copilot's indicated airspeed was available, minimum control speeds obtained by both methods were in very close agreement.

AIRSPEED CALIBRATION

Airspeed calibration data were obtained by the pacer technique. The position error was calculated by using the methods derived in reference 6. A temperature probe recovery factor of 1.0 was used for all calculations.

List of Plots

Propeller Efficiency Chart for 43E60/6917B-14 Propeller
Based on Strip Analysis Calculations Including the Blocking Effects of a Pratt and Whitney R-2800 Engine

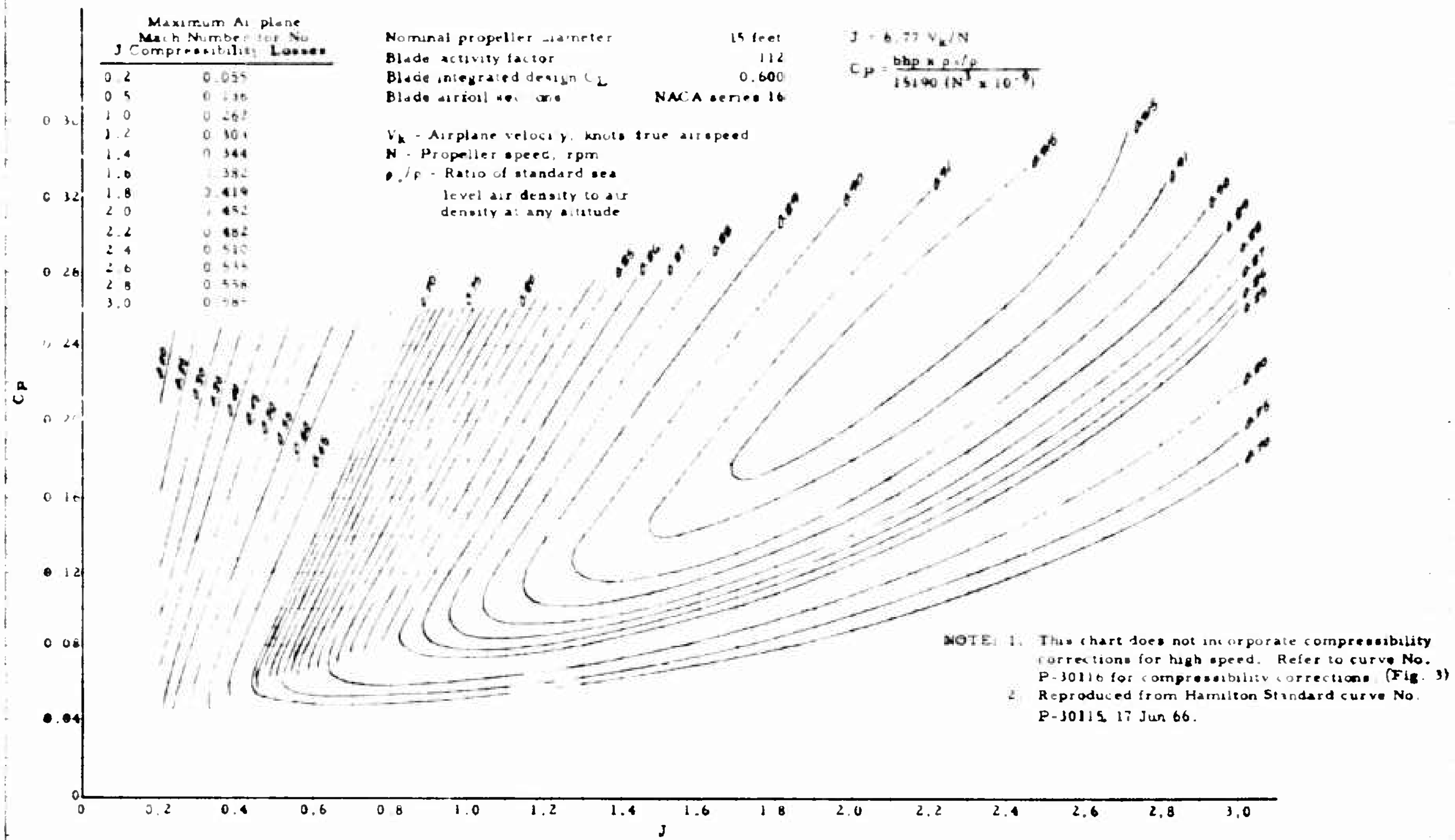


Figure 1. Propeller Efficiency Chart

Propeller Efficiency Chart for 43E60/6917B-14 Propeller
Cross Plotted from Hamilton Standard Curve No. P-30115, 17 Jun 66

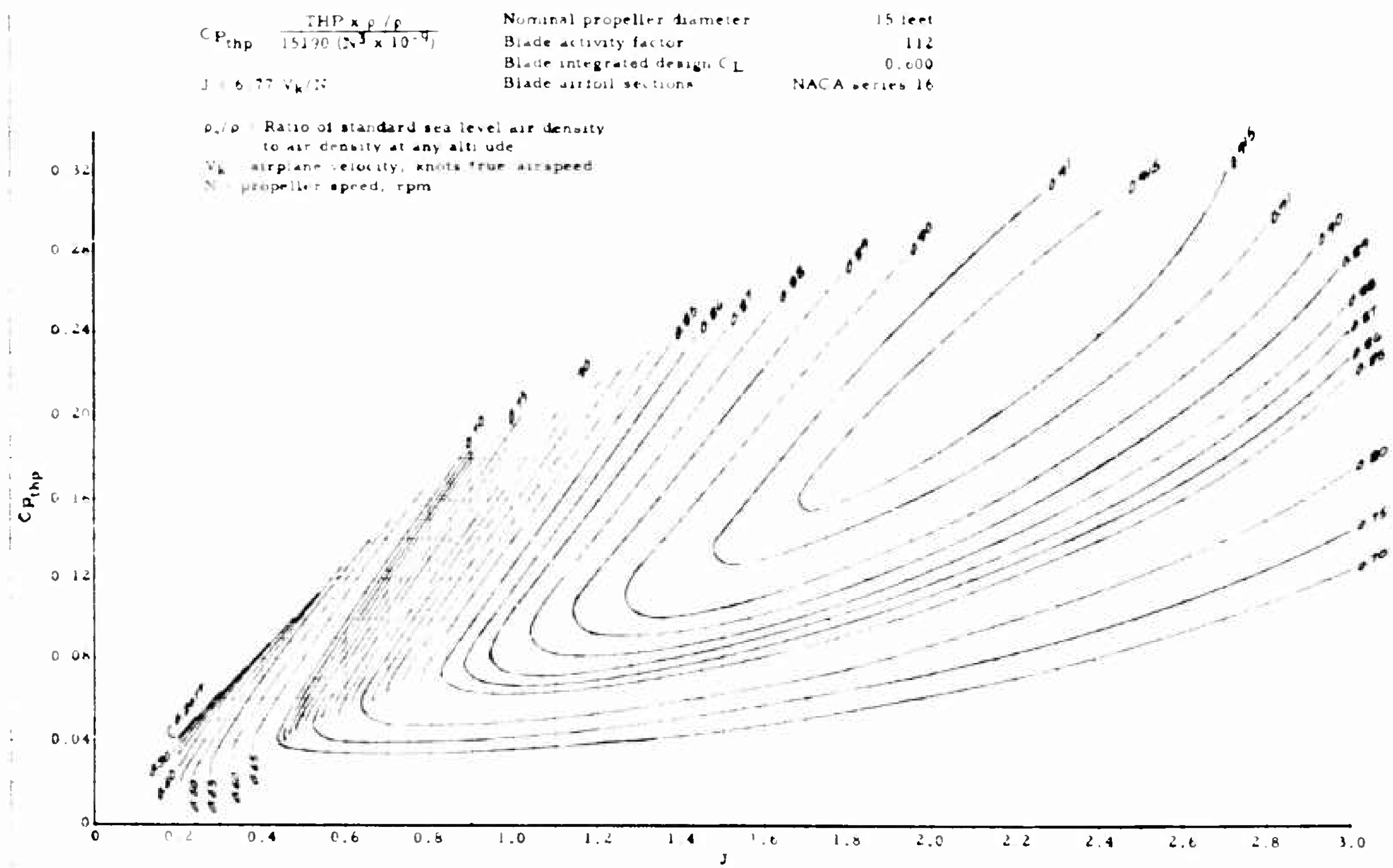


Figure 2. Propeller Efficiency Chart

Compressibility Correction Factors
for the 43E60/6917B-14 Efficiency Map
(Curve No P-30116)

$\eta_{compressible} = F_t \times \eta_{incompressible}$
MN = Airplane Mach Number
(Reproduced from Hamilton Standard Curve No. P-30116, 17 Jun 66)

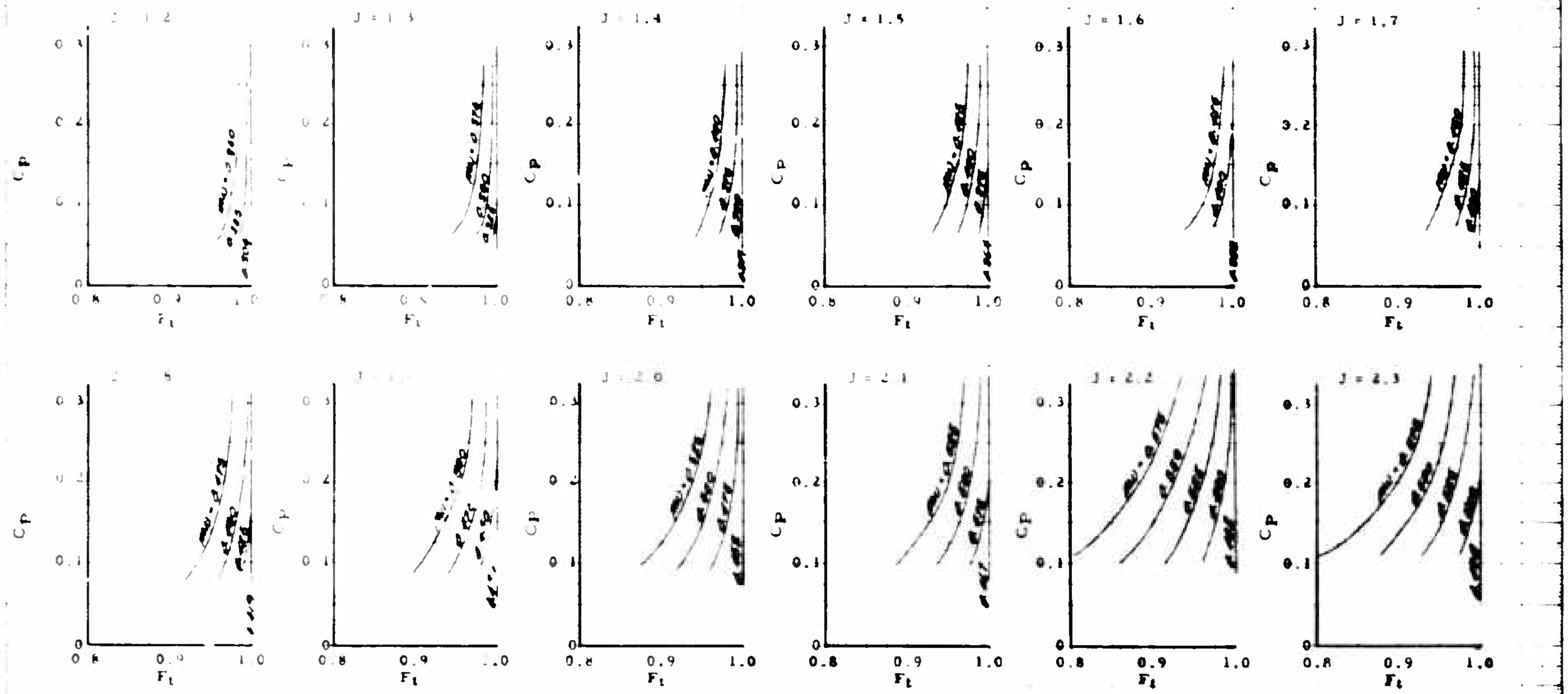


Figure 3 Compressibility Correction Factors (F_t)

C-123K USAF S/N 54-581
R2800-99W and J85-GE-17 Engines
PR-58E5 Carburetors 43E60-607 Propellers
Sea Level, Standard Day, No Wind
R2800 Engines: 2500 BHP Wet, 2300 BHP Dry at 2800 rpm
J85-GE-17 Engines: Military Rated Thrust
Cowl Flaps - TAKEOFF Oil Cooler - COLD
Wing Flaps - TAKEOFF (20 deg)

Symbol	Gross Weight (lb)	ADI
○	60 000	off
△	60 000	on
□	45 000	on

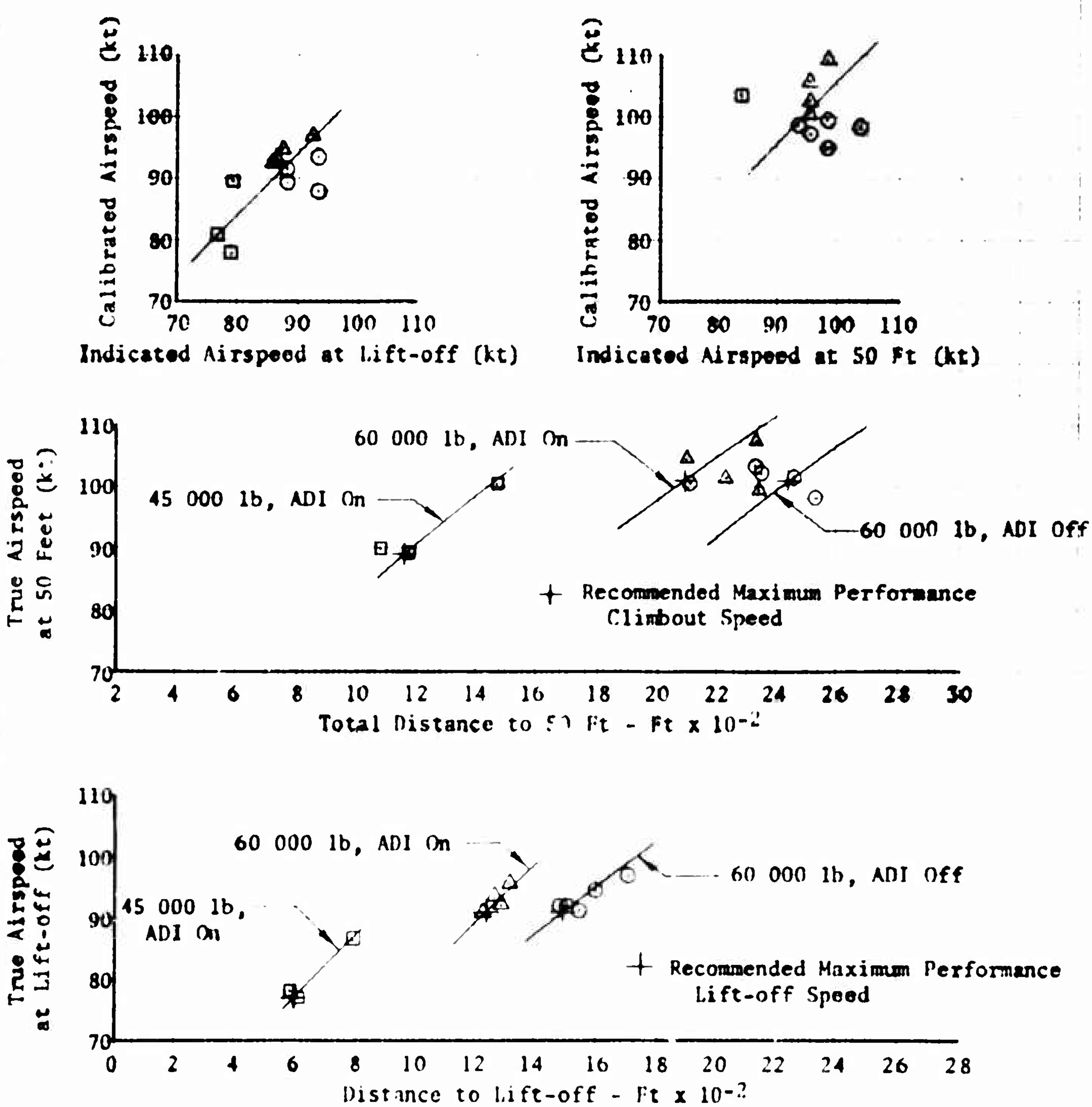


Figure 4. Takeoff Performance

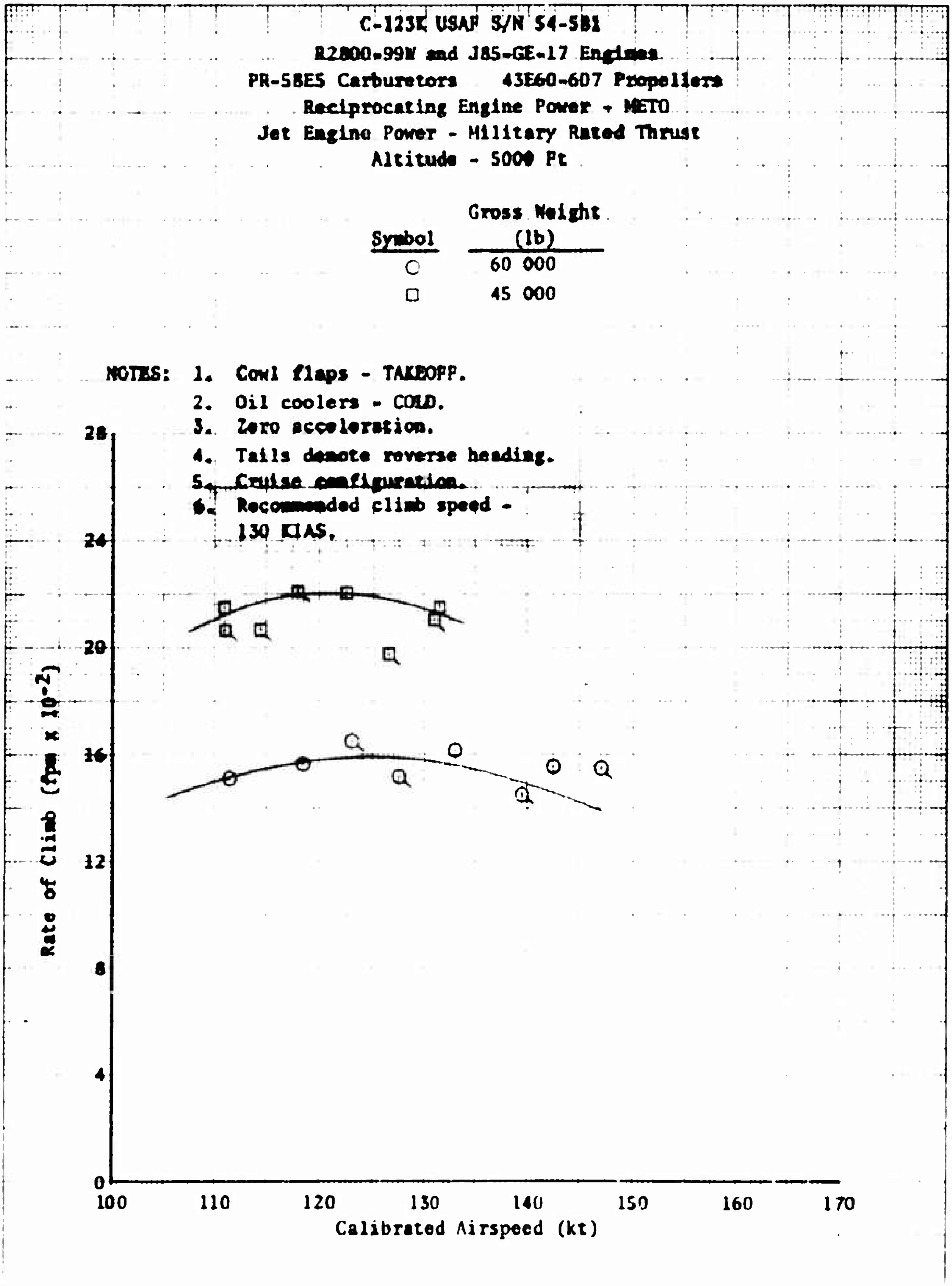


Figure 5. Sawtooth Climb Performance

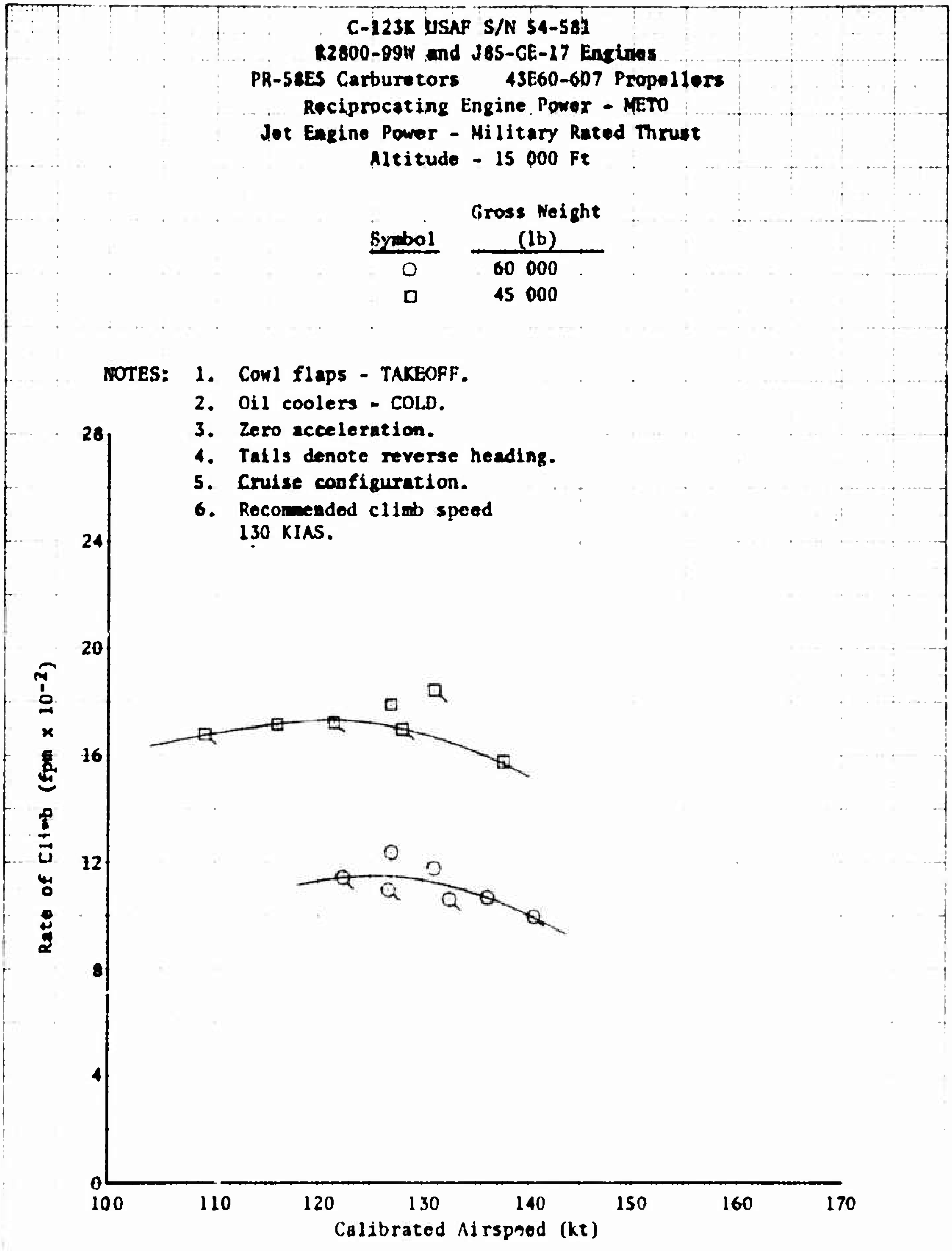


Figure 6. Sawtooth Climb Performance

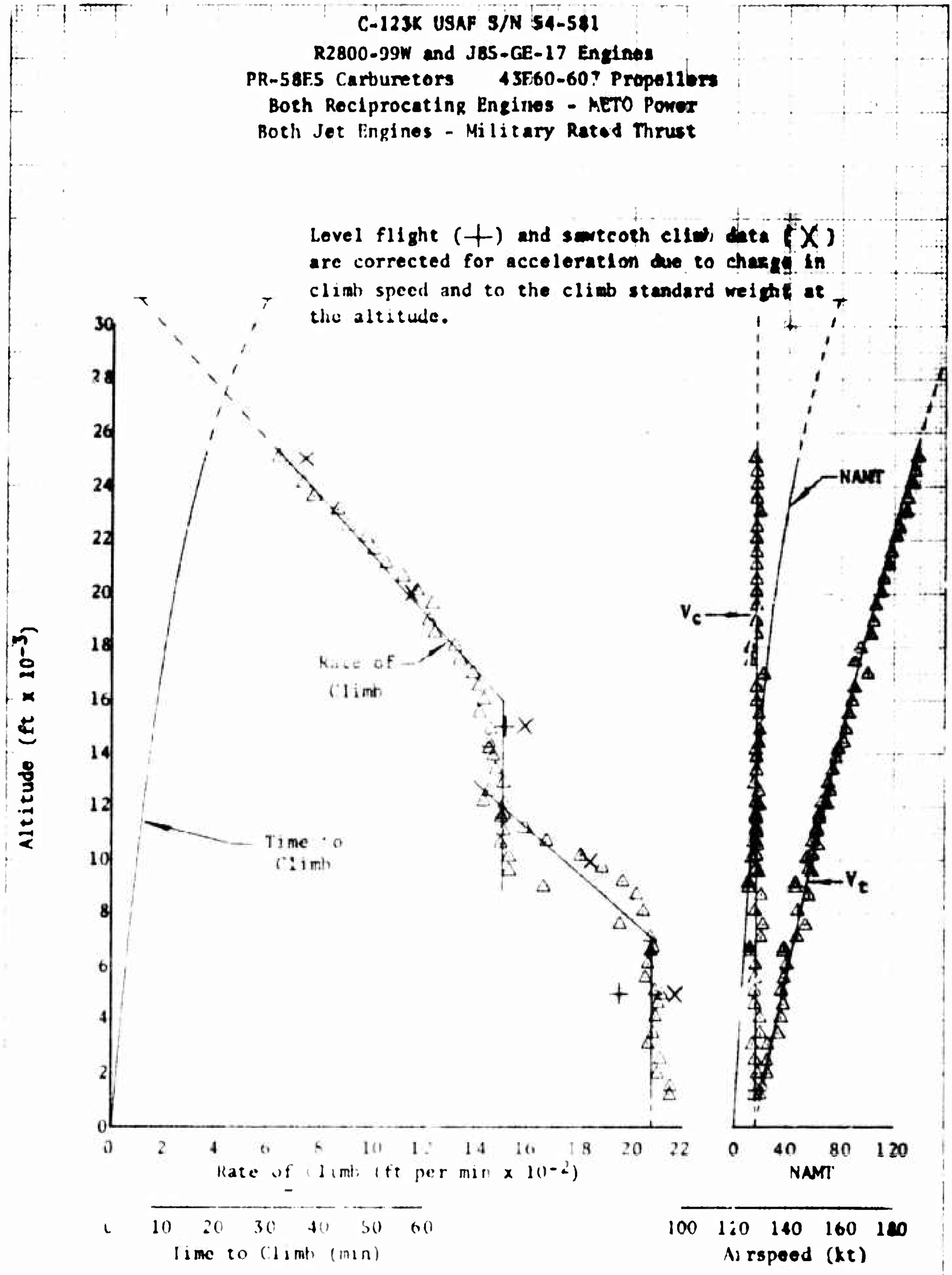


Figure 7. Climb Performance

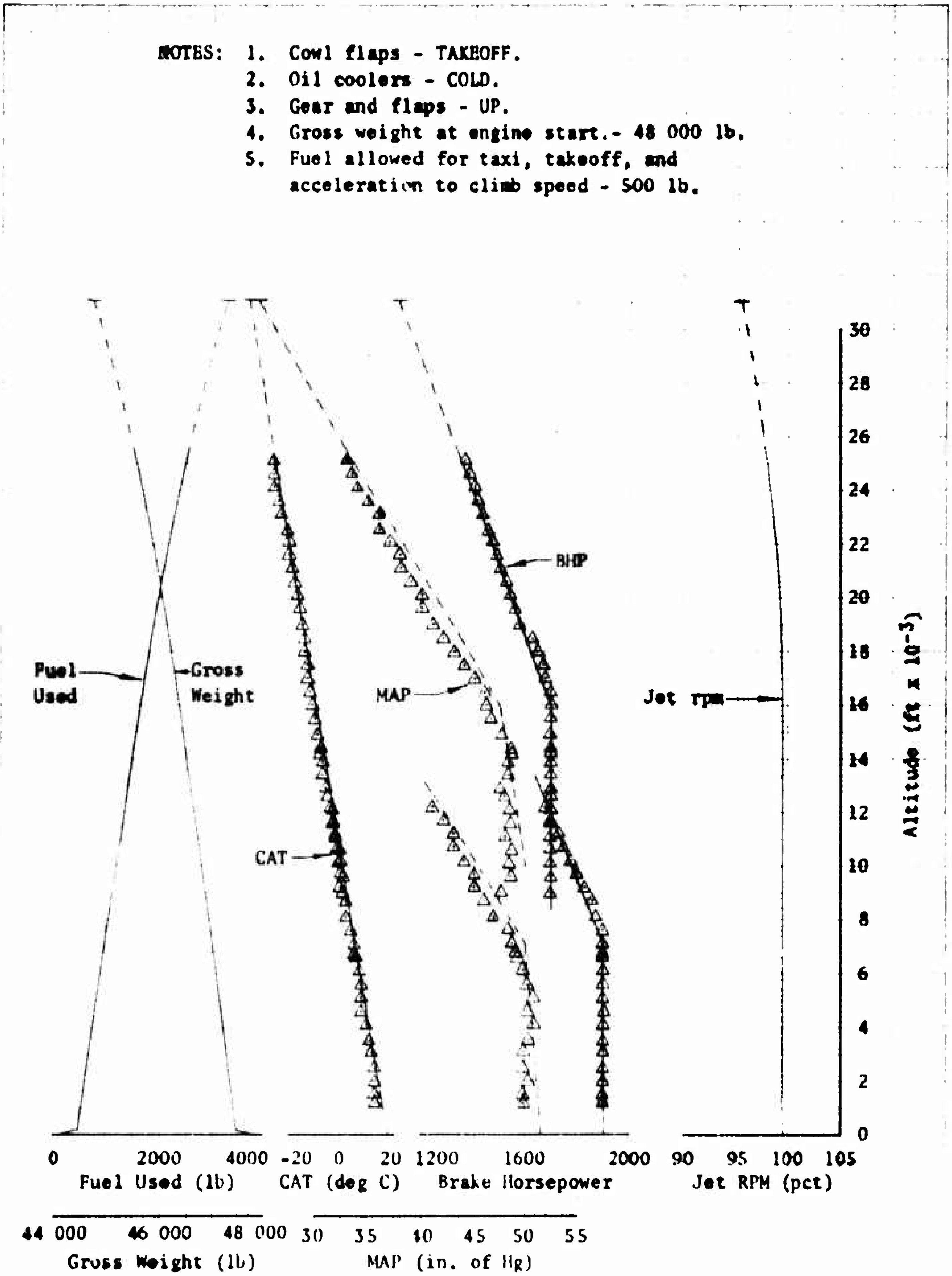


Figure 7. Climb Performance (concluded)

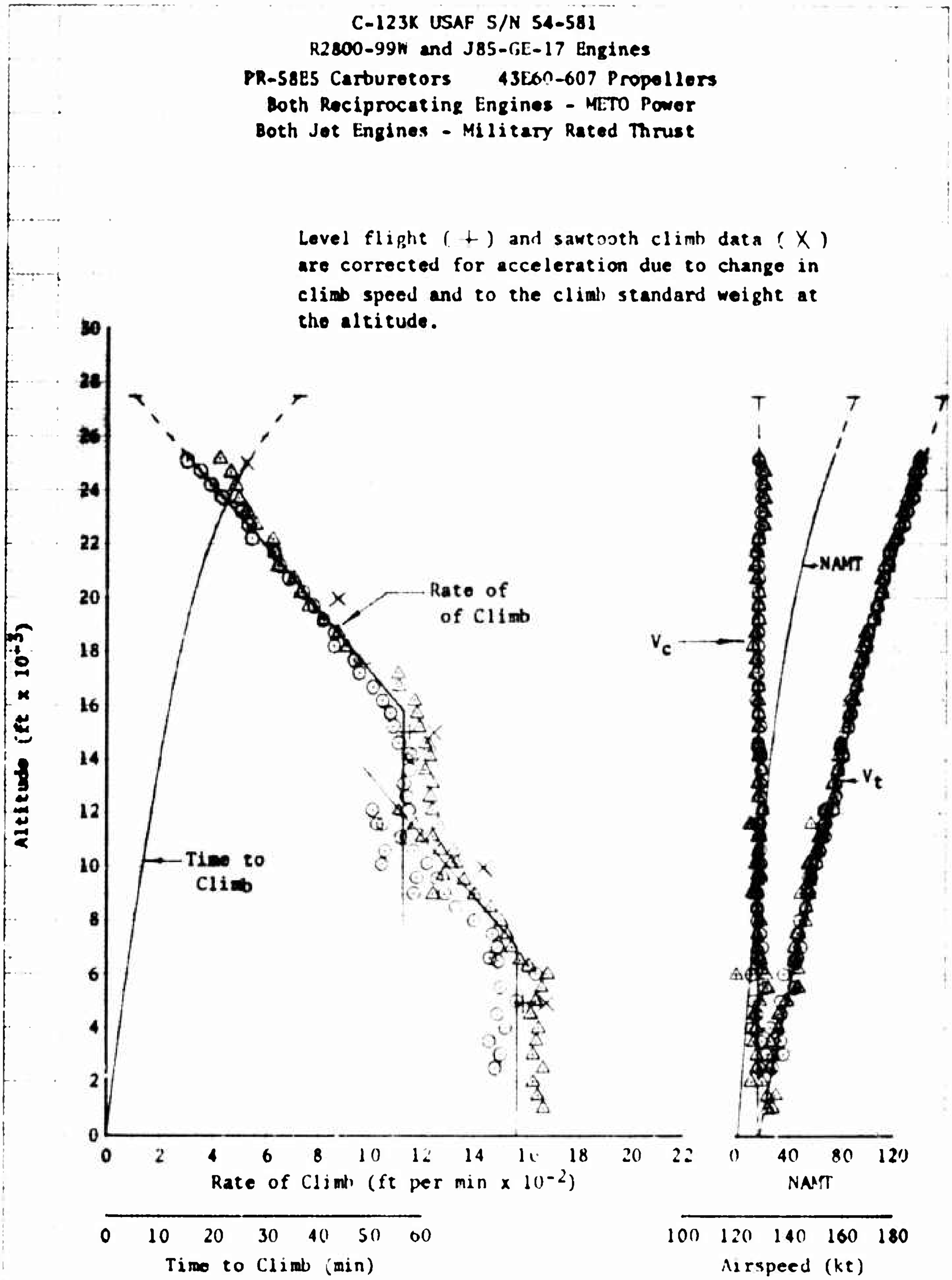


Figure 8. Climb Performance

NOTES: 1. Cowl flaps - TAKEOFF.
2. Oil coolers - COLD.
3. Gear and flaps - UP.
4. Gross weight at engine start.- 60 000 lb.
5. Fuel allowed for taxi, takeoff, and acceleration to climb speed - 500 lb.

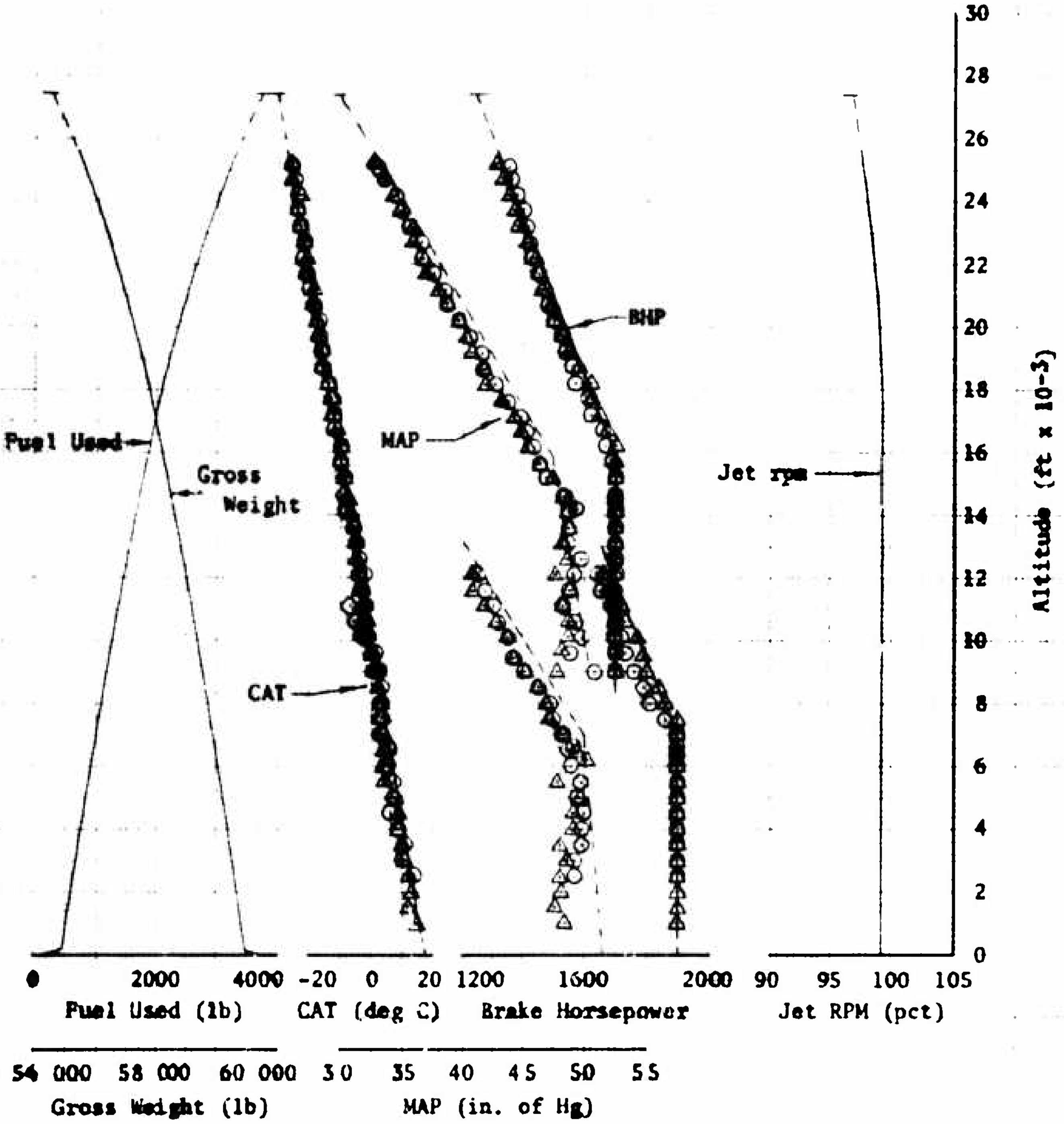


Figure 8. Climb Performance (concluded)

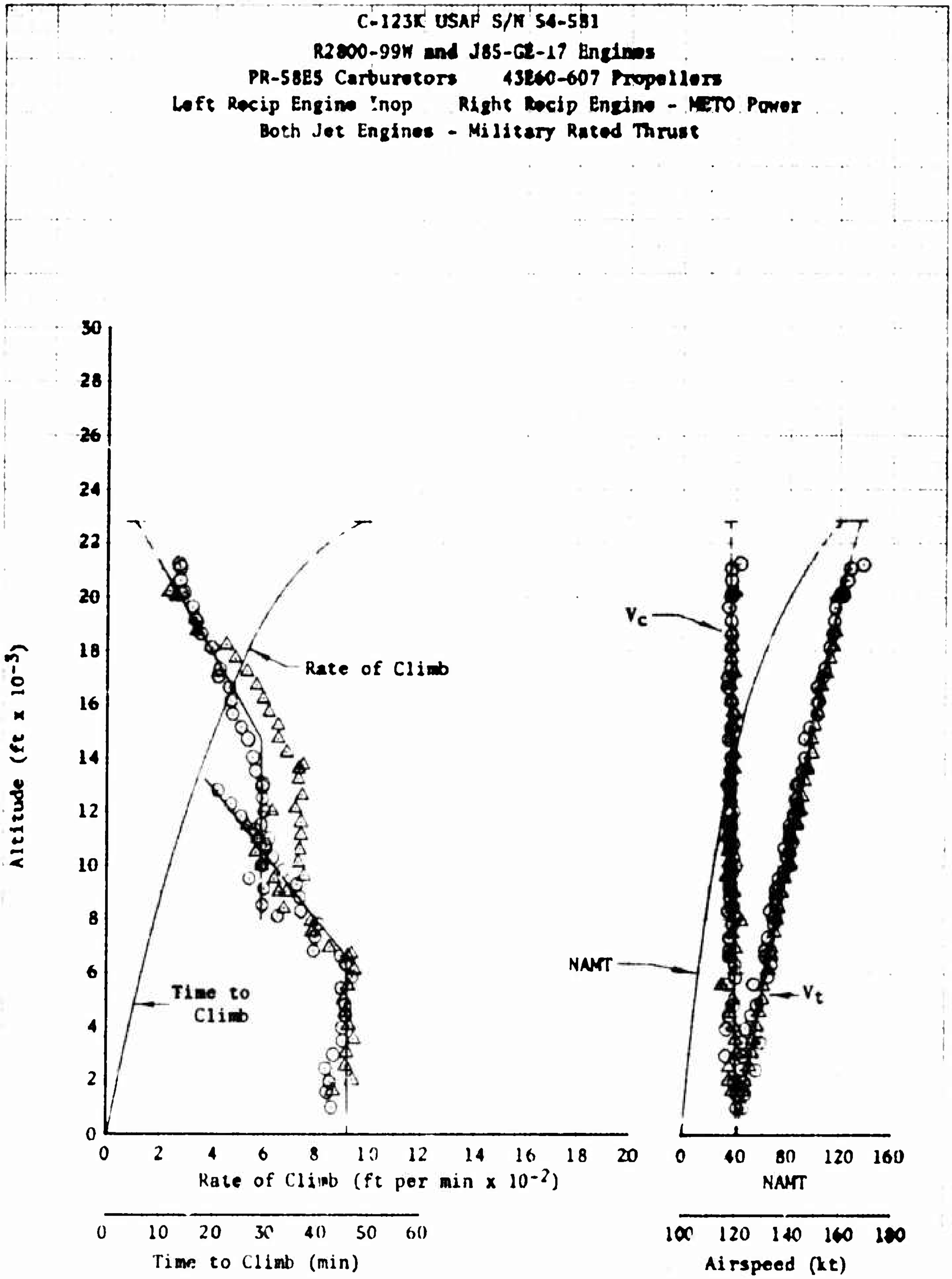


Figure 9. Climb Performance

NOTES: 1. Cowl flaps - TAKEOFF.
2. Oil coolers - COLD.
3. Gear and flaps - UP.
4. Gross weight at engine start - 56 000 lb.
5. Fuel allowed for taxi, takeoff, and acceleration to climb speed - 500 lb.

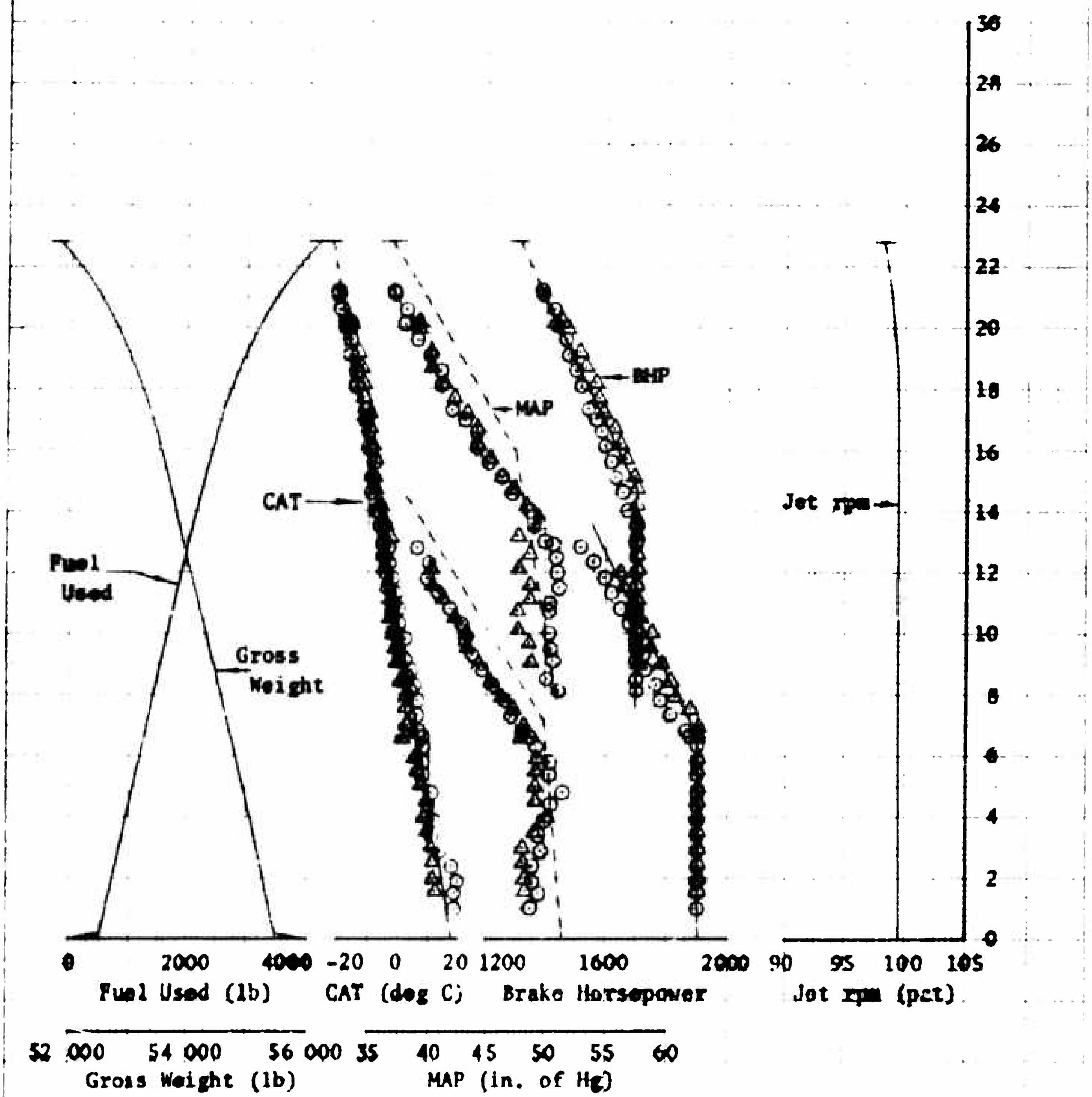


Figure 9. Climb Performance (concluded)

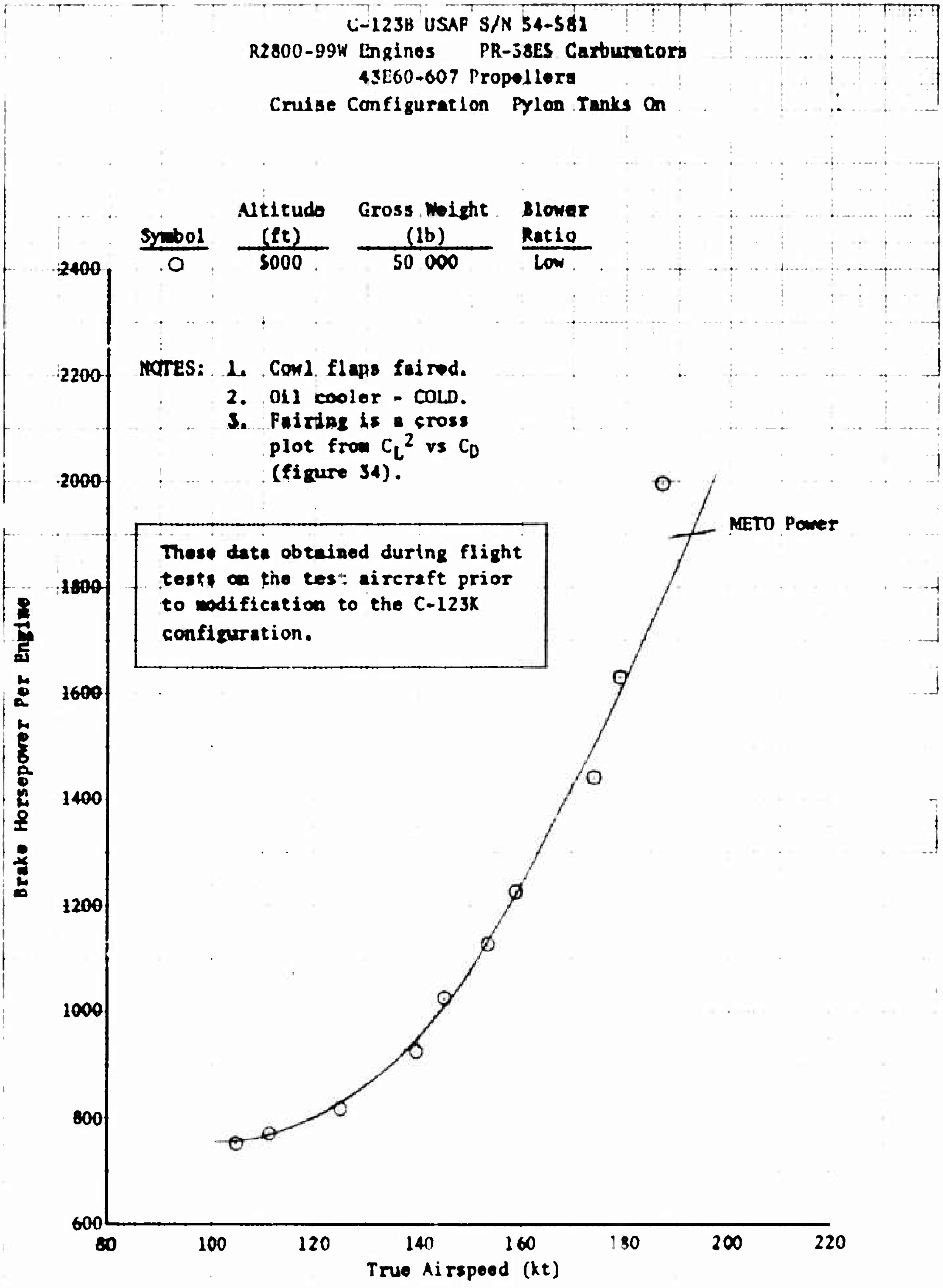


Figure 10. Level Flight Performance

C-123B USAF S/N 54-581
R2800-99W Engines PR-58E5 Carburetors
43E60-607 Propellers
Cruise Configuration Pylon Tanks On

Symbol	Altitude (ft)	Gross Weight (lb)	Blower Setting
○	20 000	40 000	High

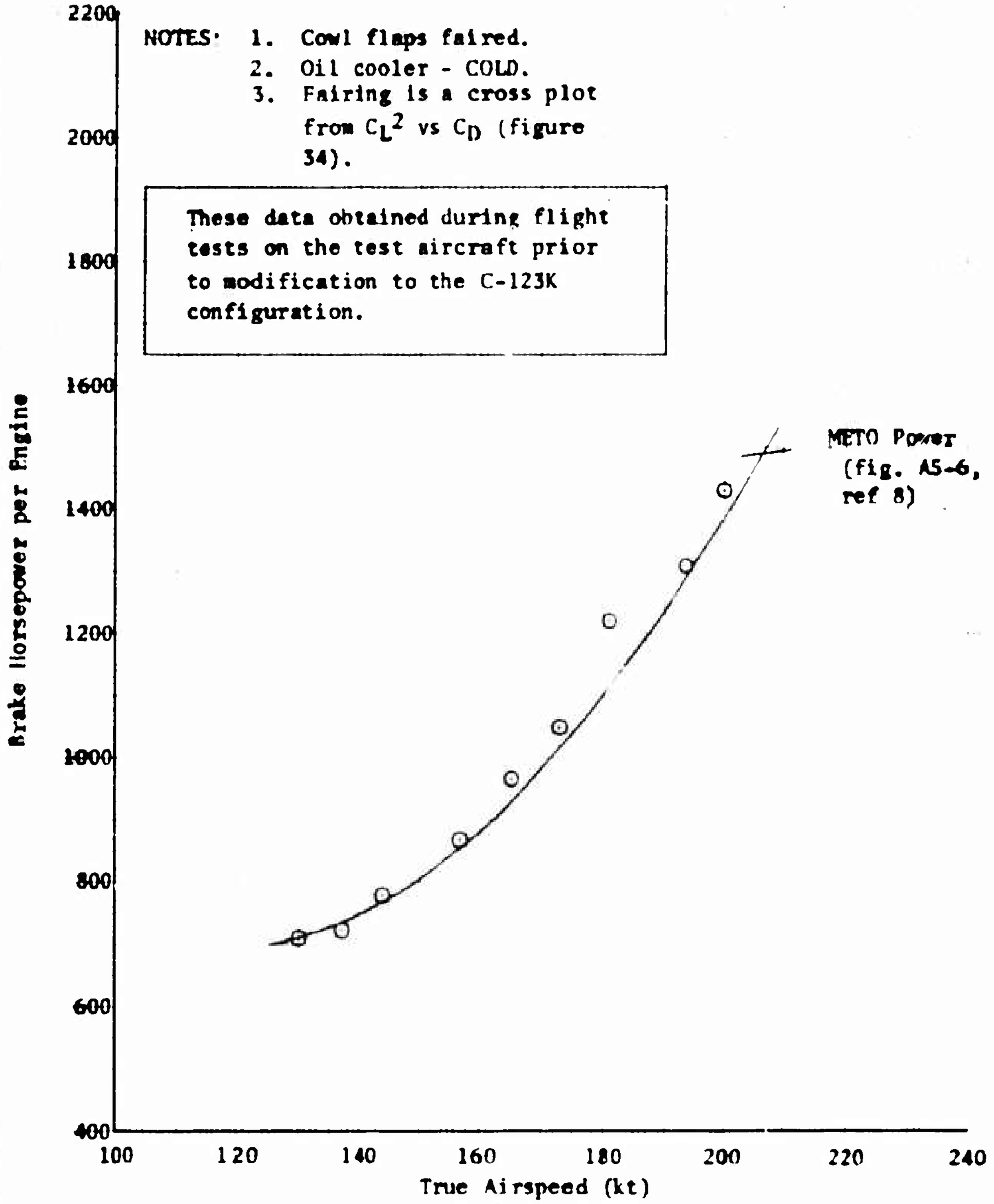


Figure 11. Level Flight Performance

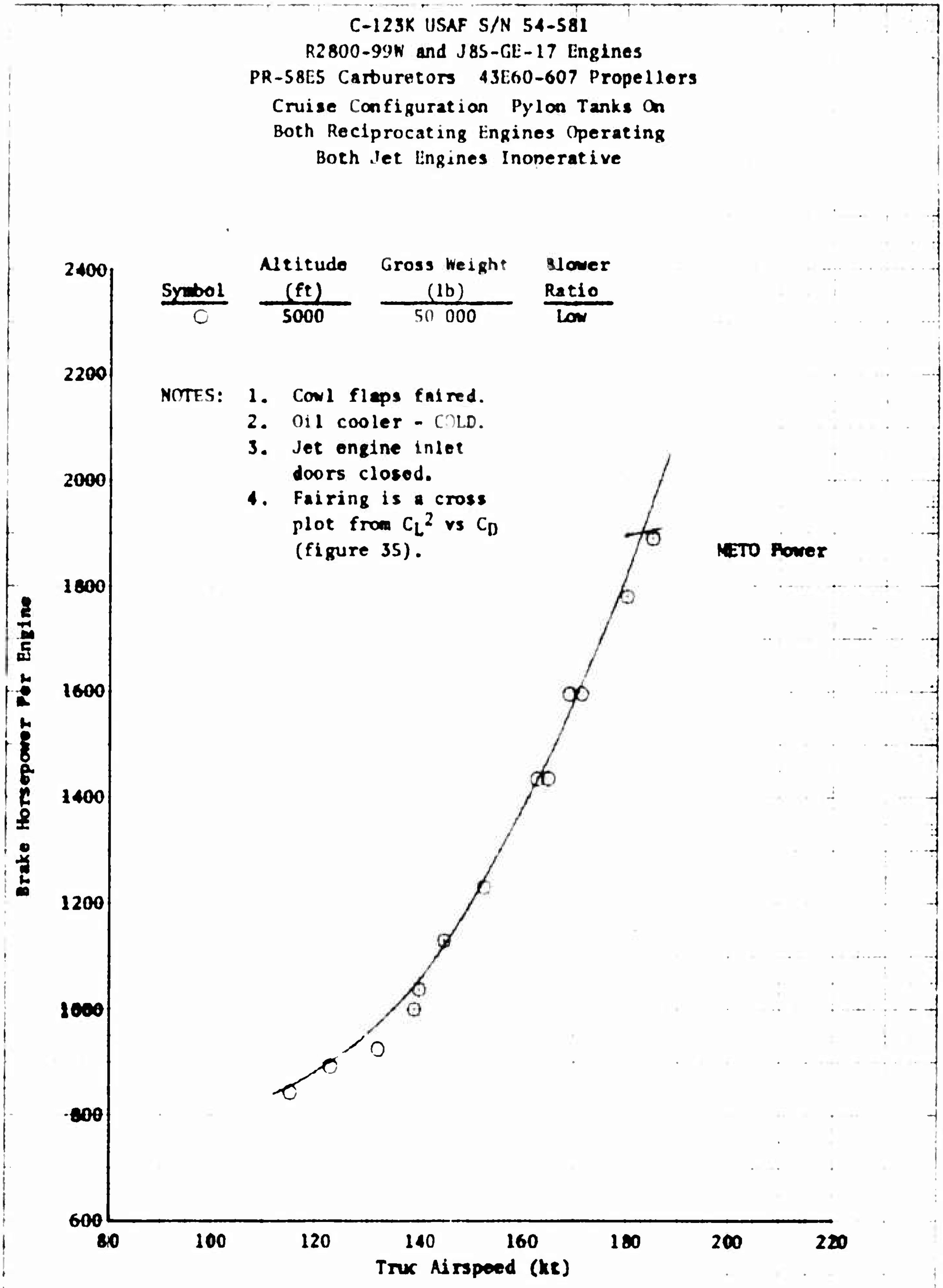


Figure 12. Level Flight Performance

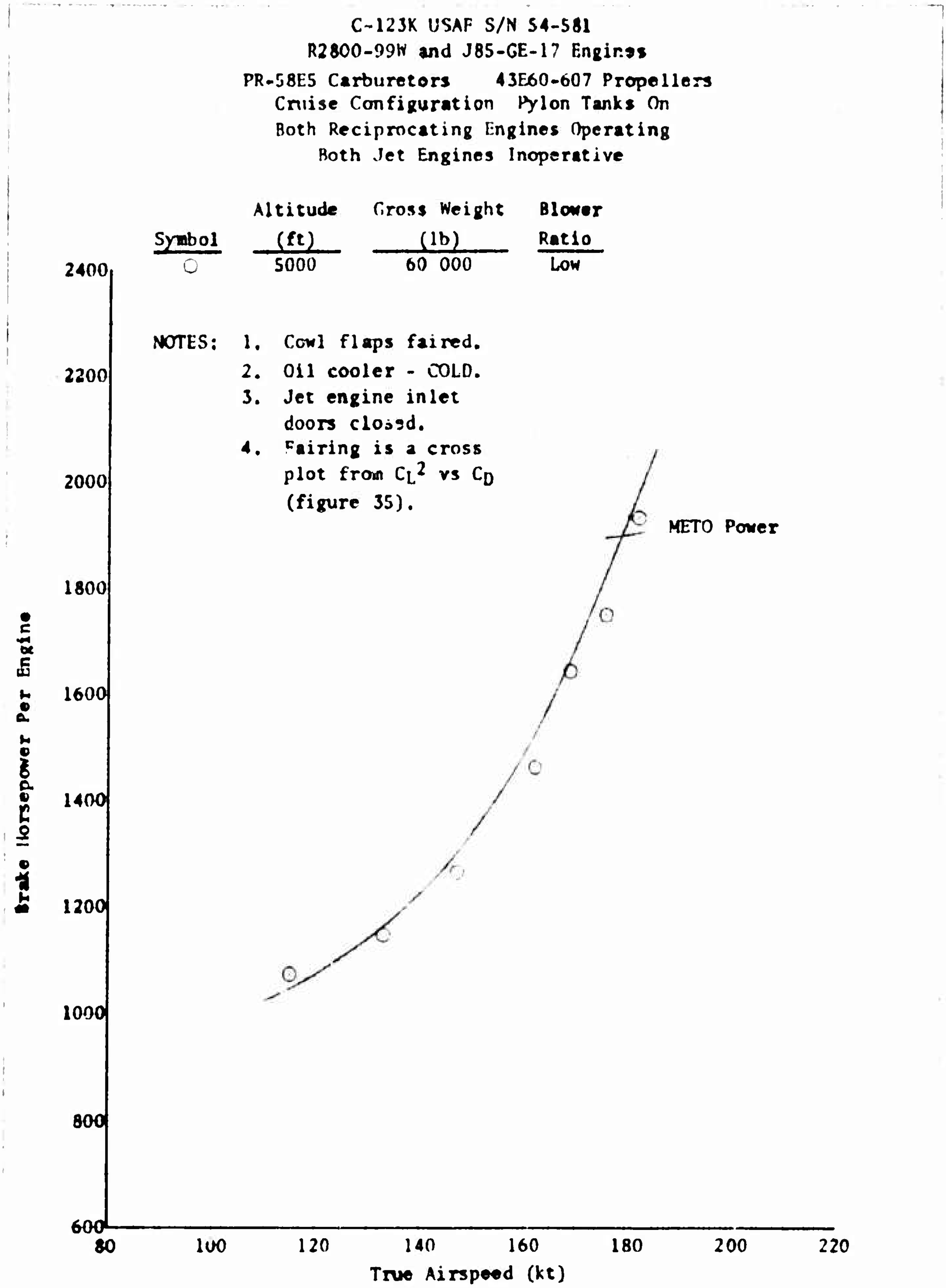


Figure 13. Level Flight Performance

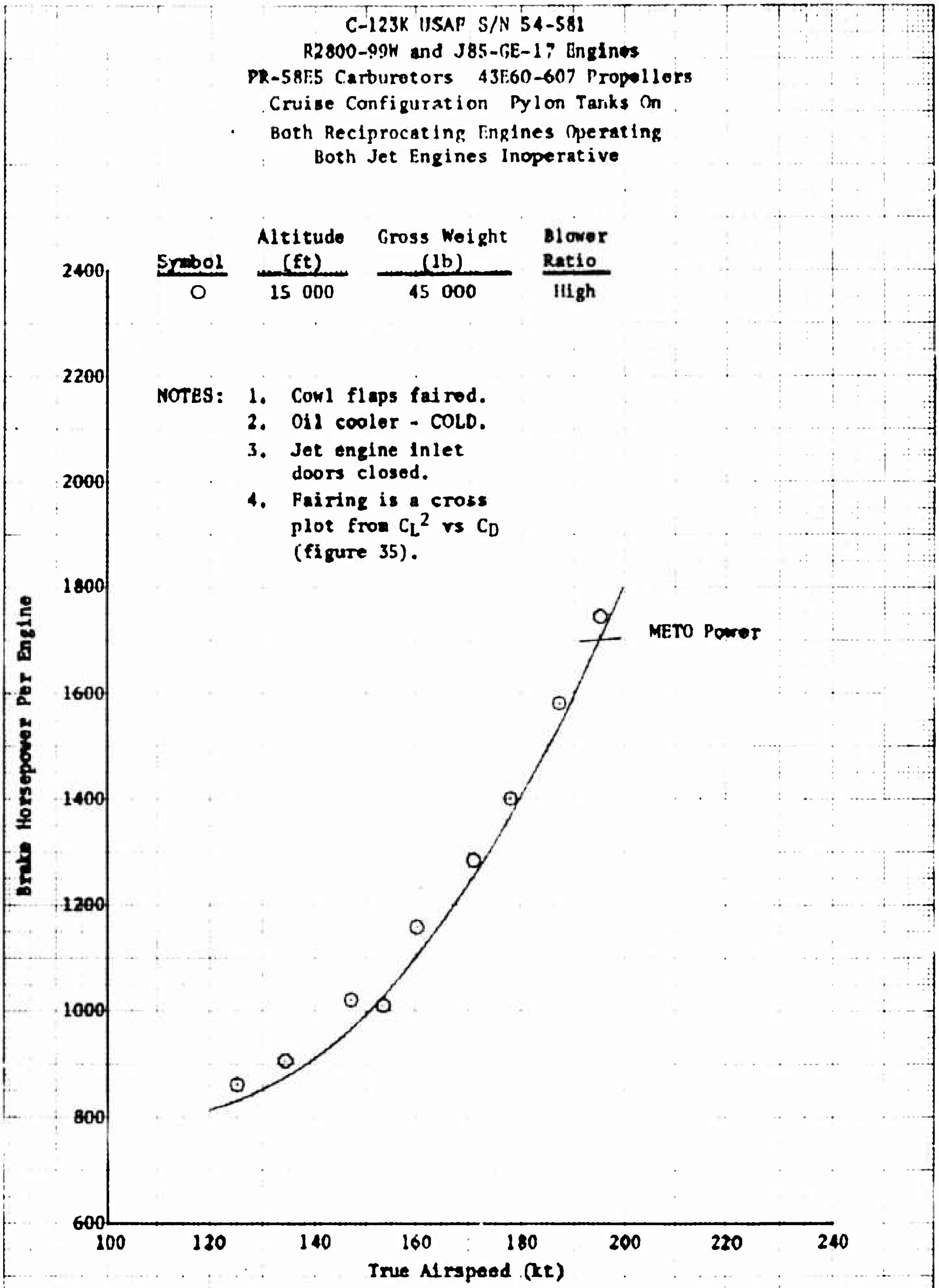


Figure 14. Level Flight Performance

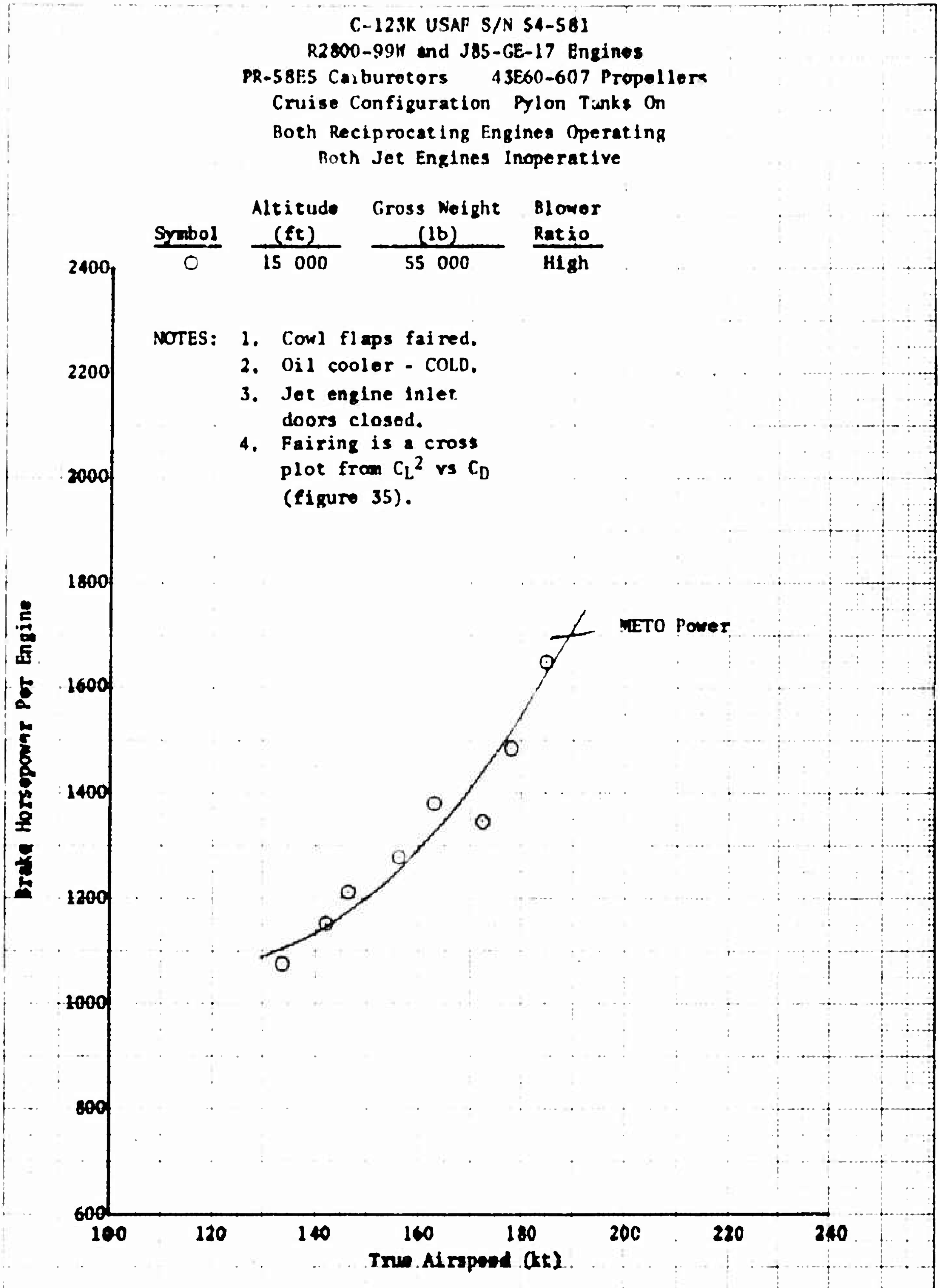


Figure 15. Level Flight Performance

C-123K USAF S/N 54-581
R2800-99W and J85-GE-17 Engines
PR-58E5 Carburetors 43E60-607 Propellers
Cruise Configuration Pylon Tanks On
Both Reciprocating Engines Operating
Both Jet Engines Inoperative

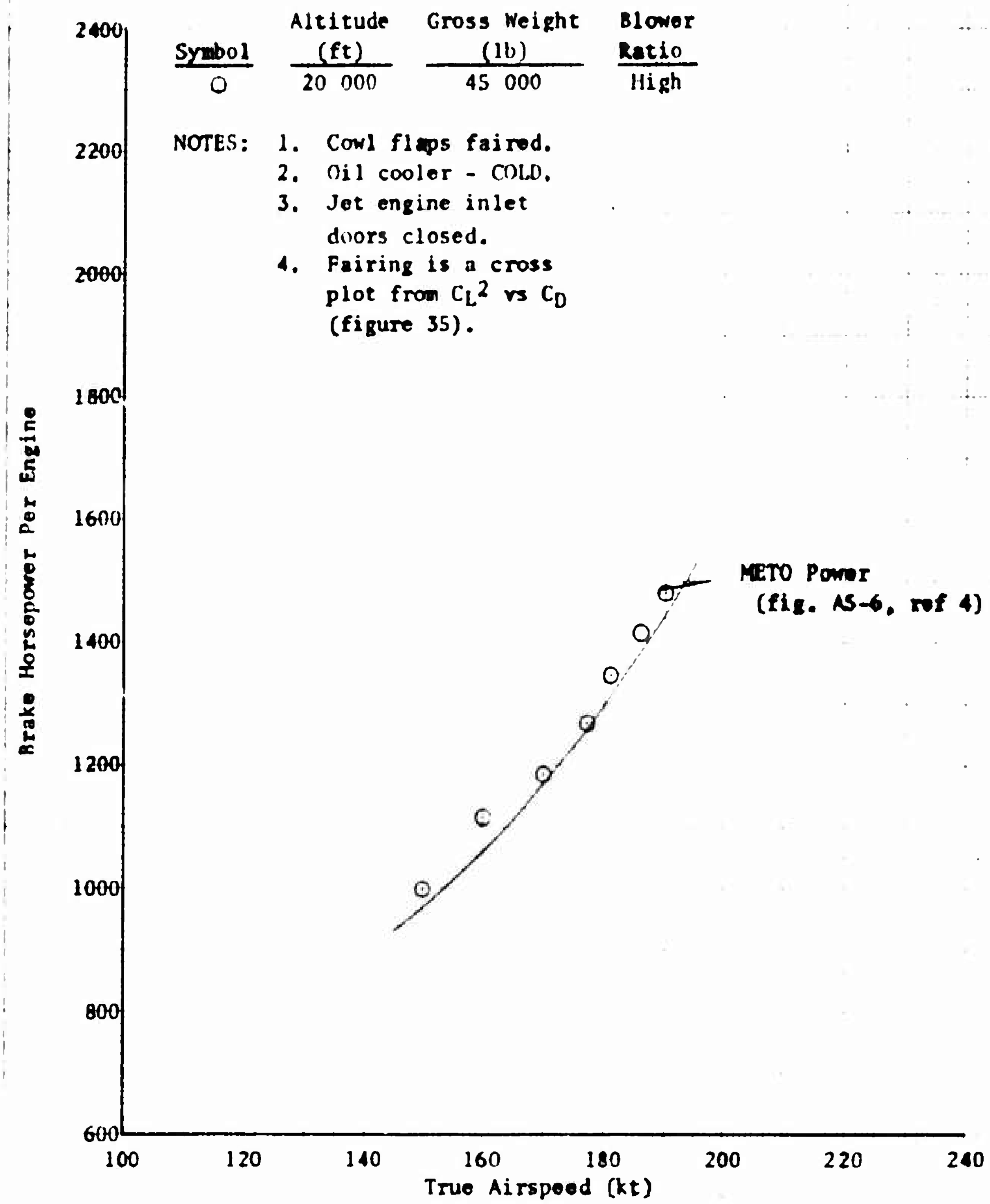


Figure 16. Level Flight Performance

C-123K USAF S/N 54-581
R2800-99W and J85-GE-17 Engines
PR-58E5 Carburetors 43E60-607 Propellers
Cruise Configuration Pylon Tanks On
Both Reciprocating Engines Operating
Both Jet Engines - 90-pct RPM

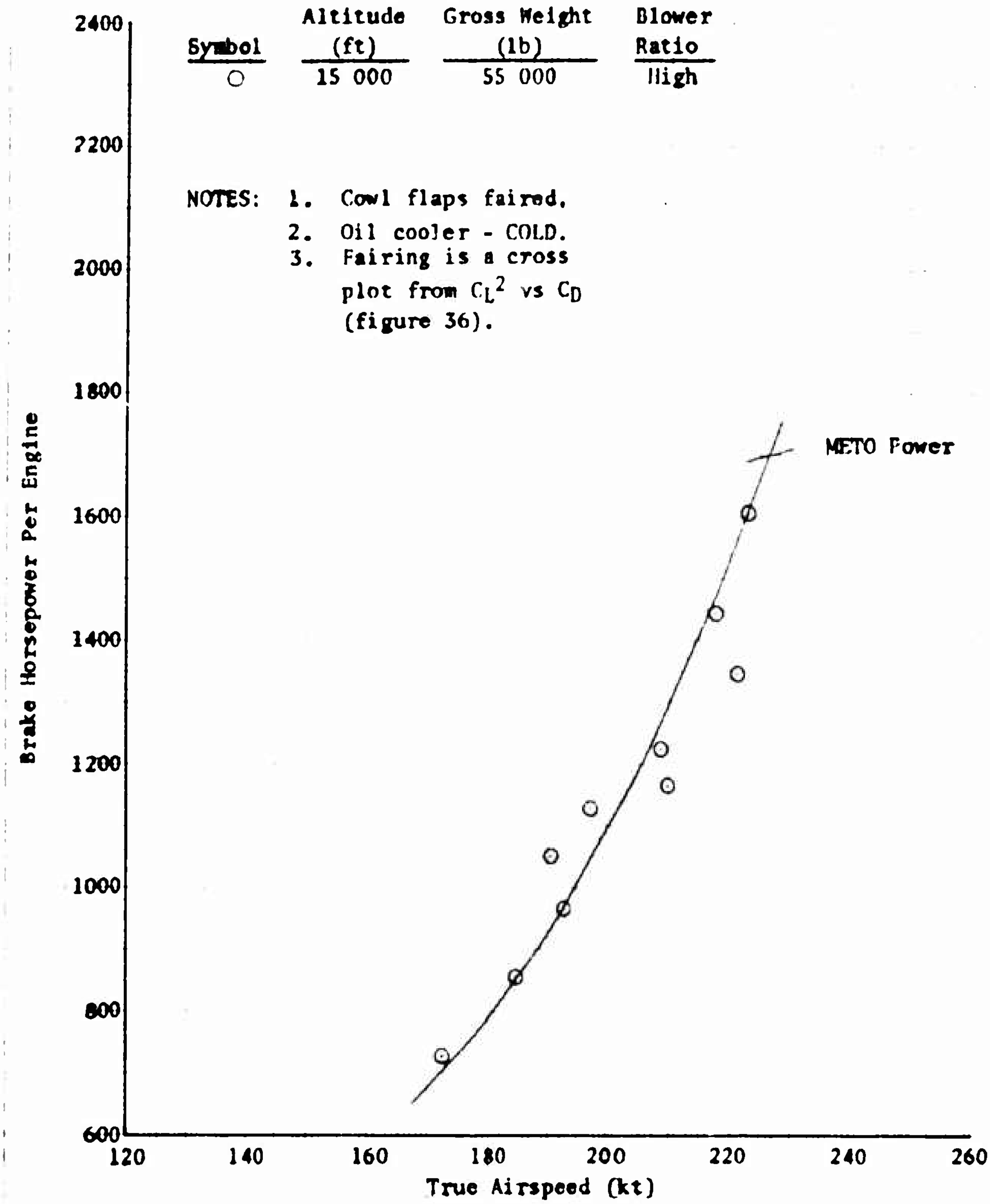


Figure 17. Level Flight Performance

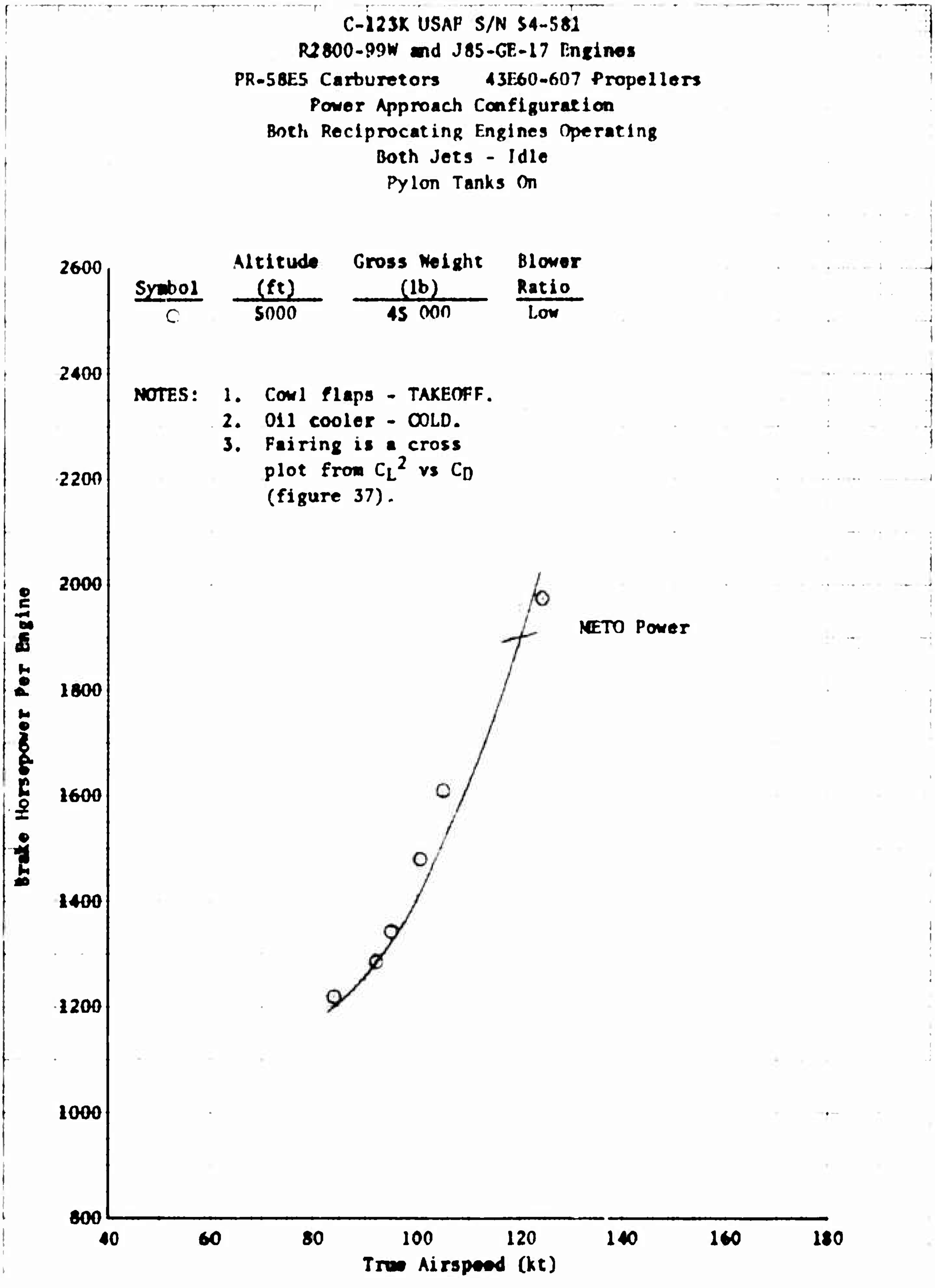


Figure 18. Level Flight Performance

C-123K USAF S/N 54-581
R2800-99W and J85-GE-17 Engines
PR-58E5 Carburetors 43E60-607 Propellers
Cruise Configuration Pylon Tanks On
Both Reciprocating Engines Operating
Both Jet Engines Inoperative

Altitude (ft)	Gross Weight (lb)	Blower Ratio
5000	50 000	Low

Symbol	Mixture Setting
○	Auto rich
□	Manual lean

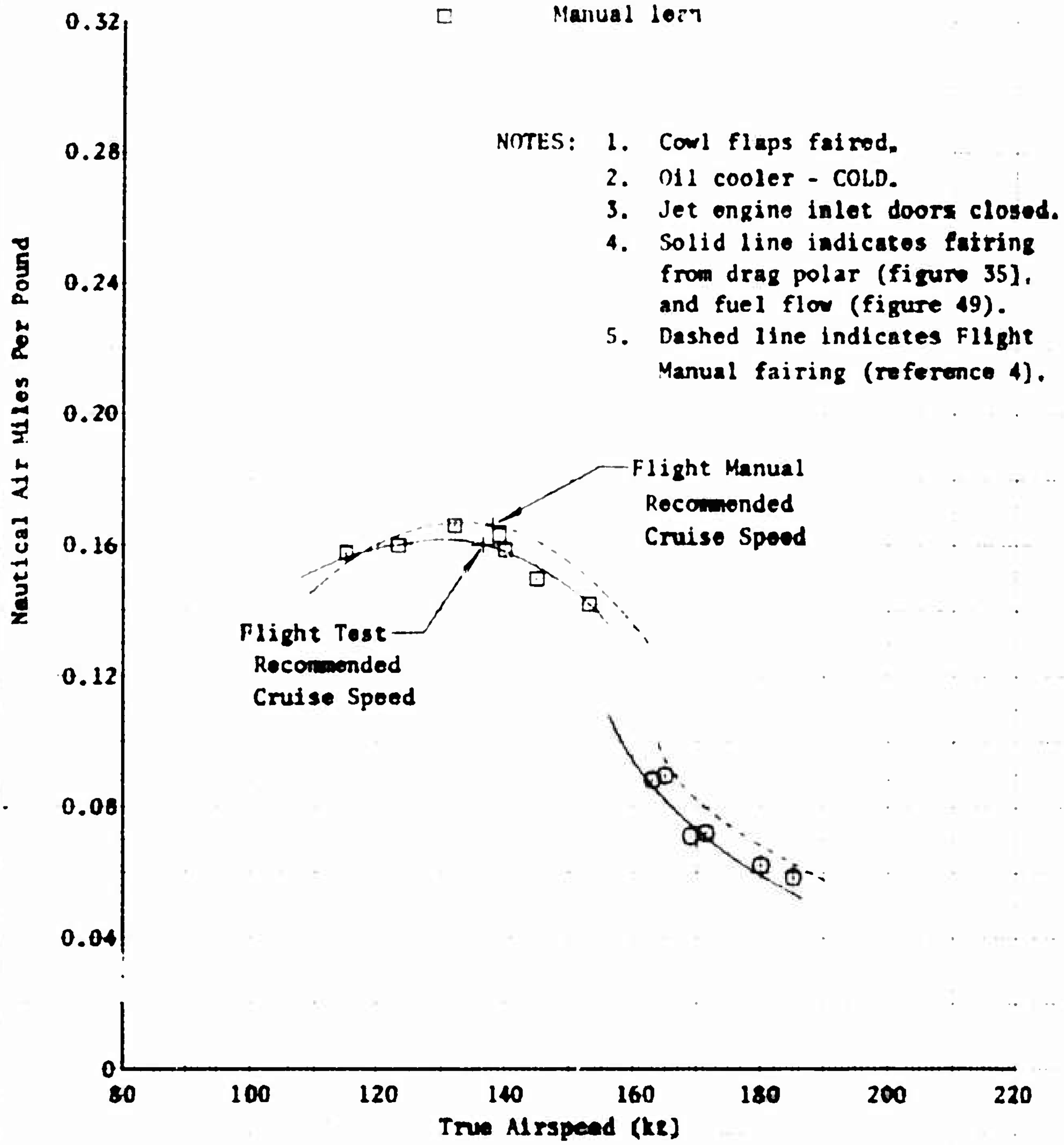


Figure 19. Specific Range

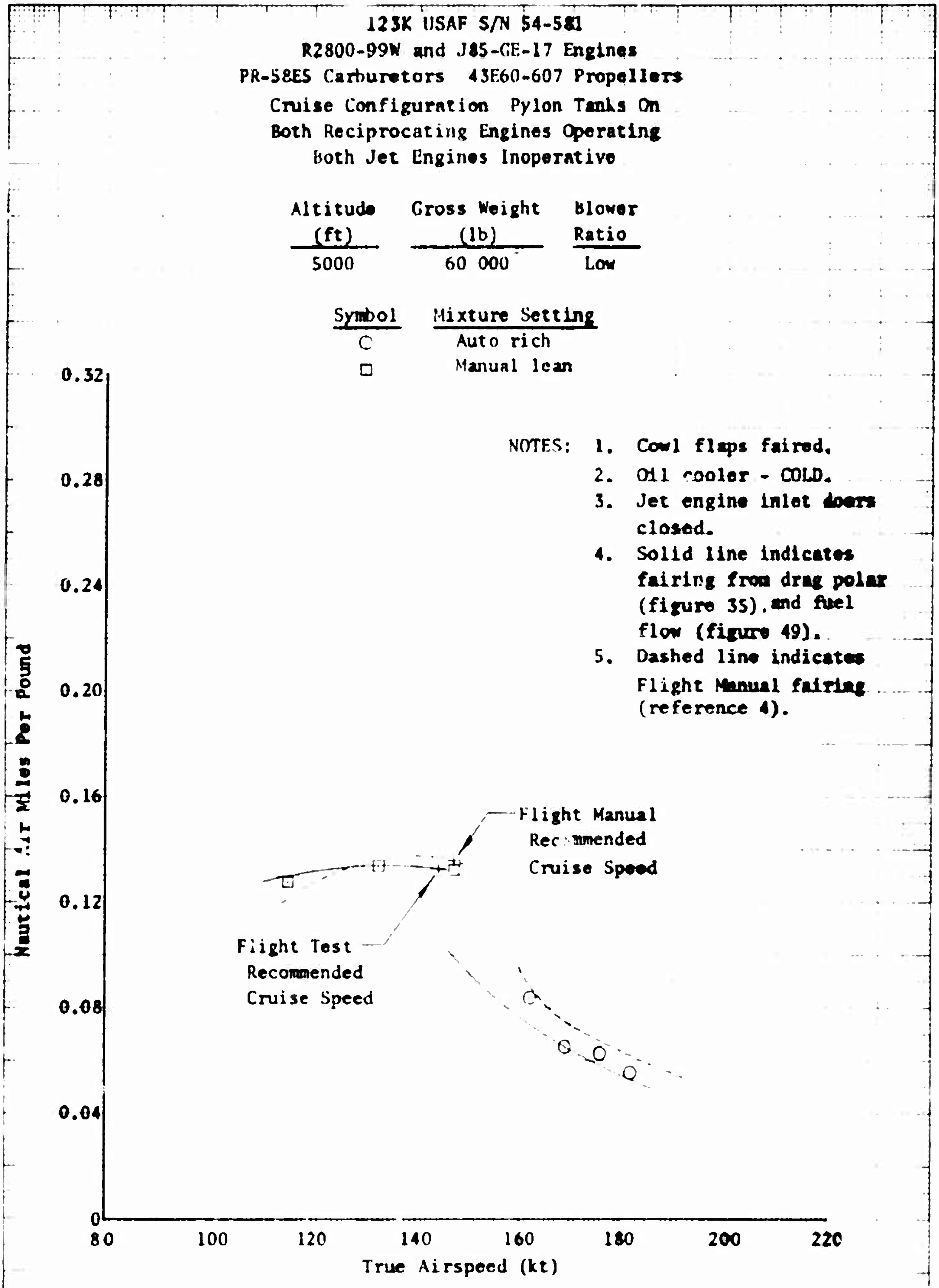


Figure 20. Specific Range

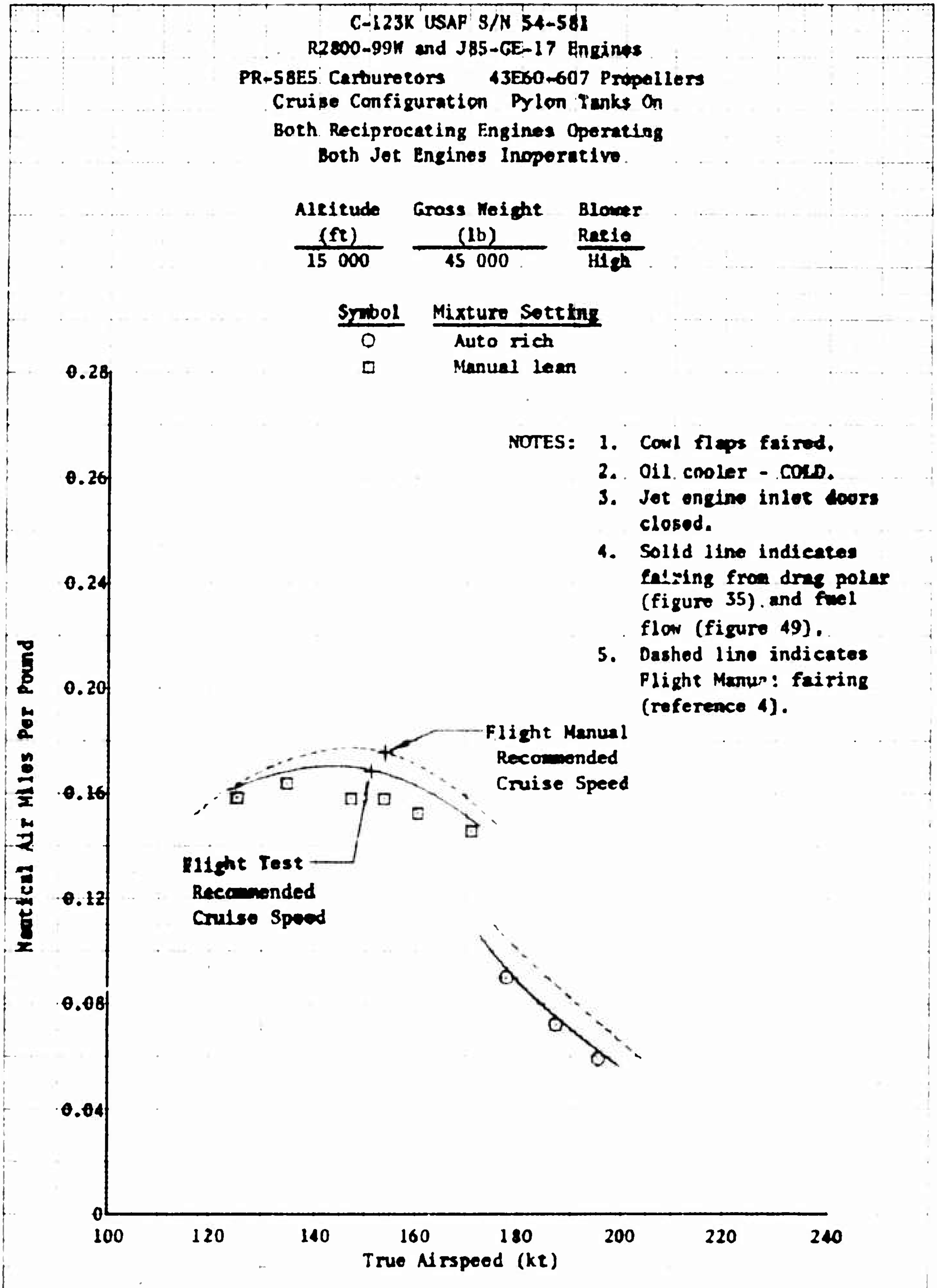


Figure 21. Specific Range

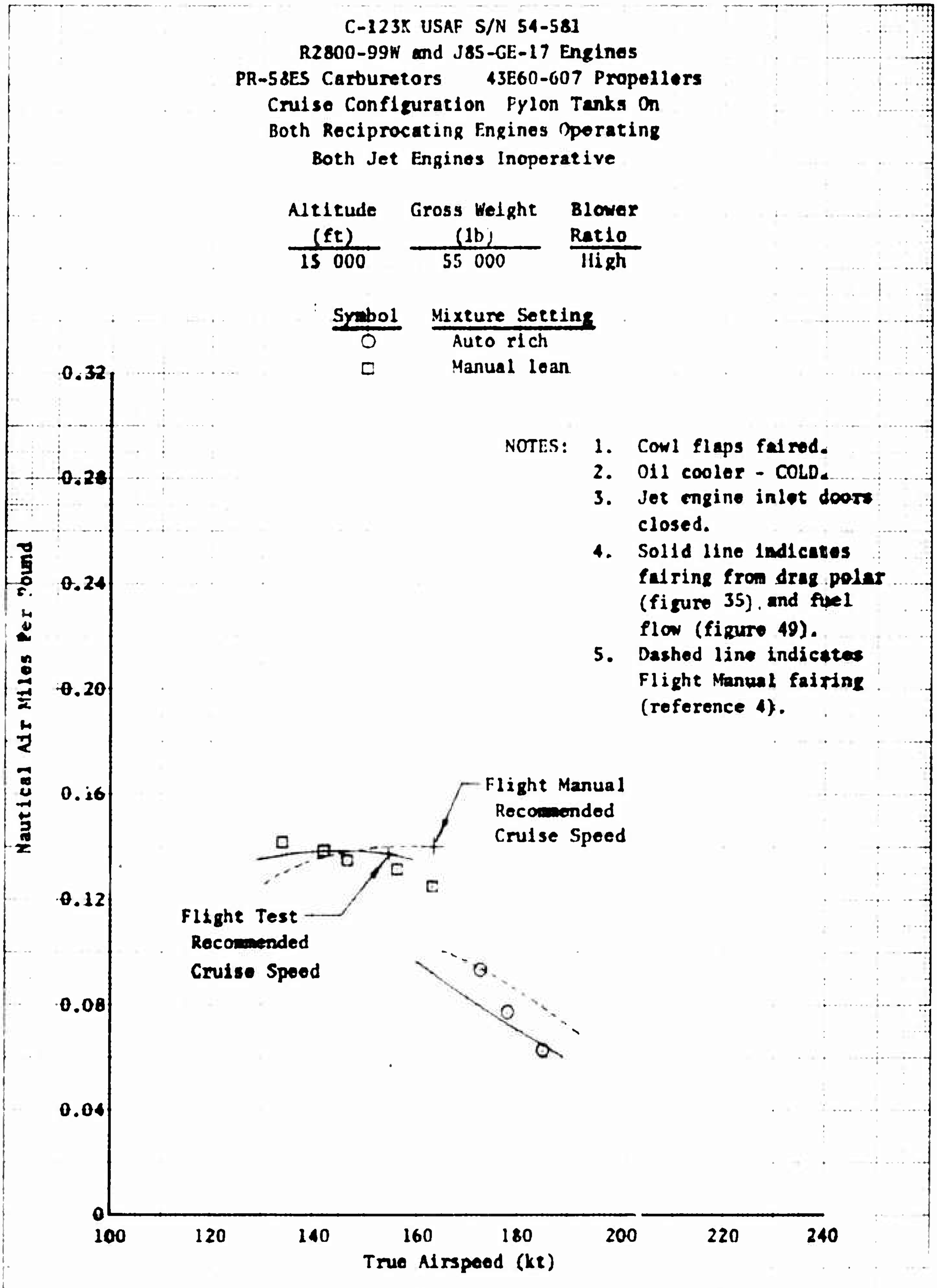


Figure 22. Specific Range

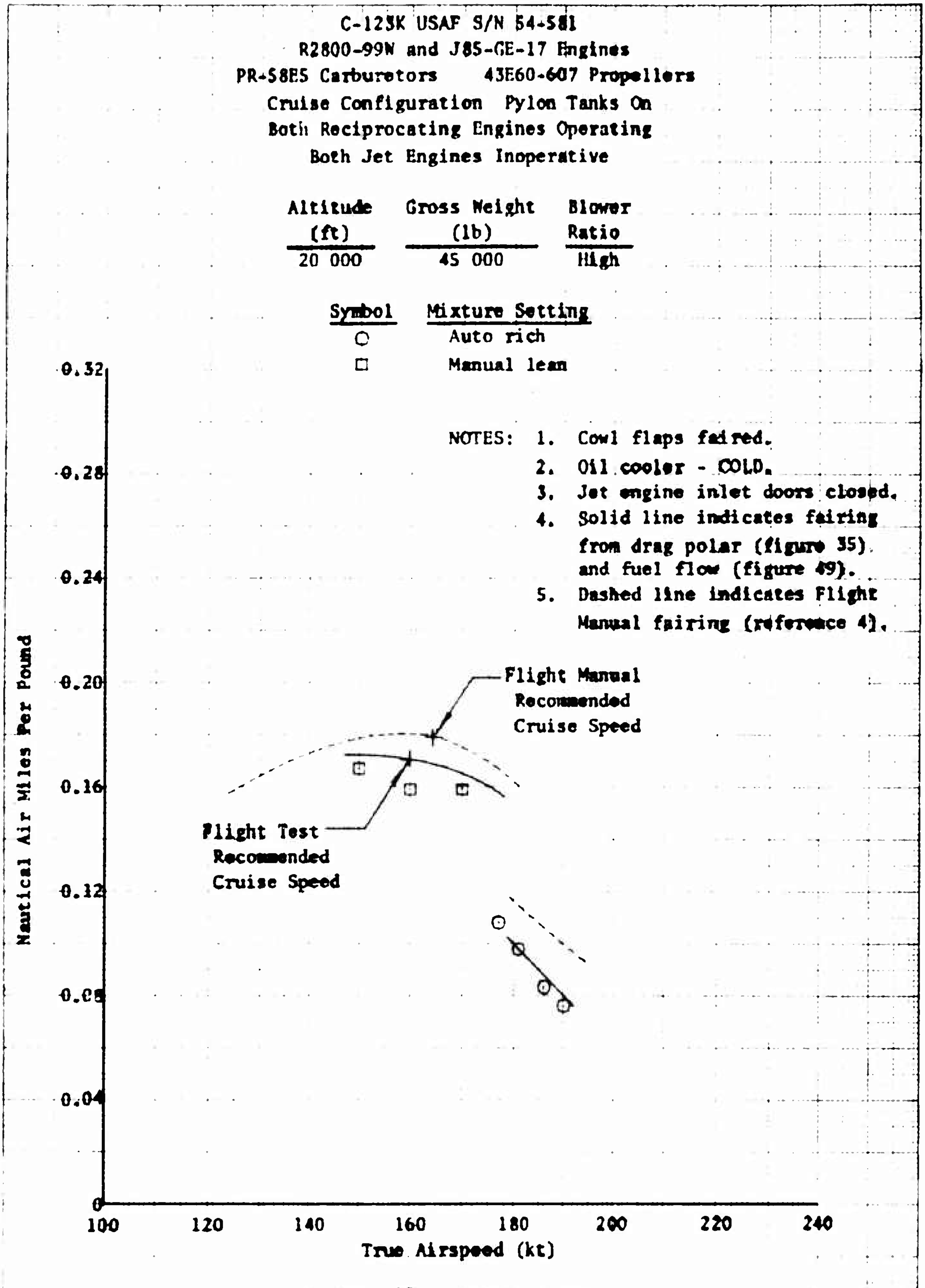


Figure 23. Specific Range

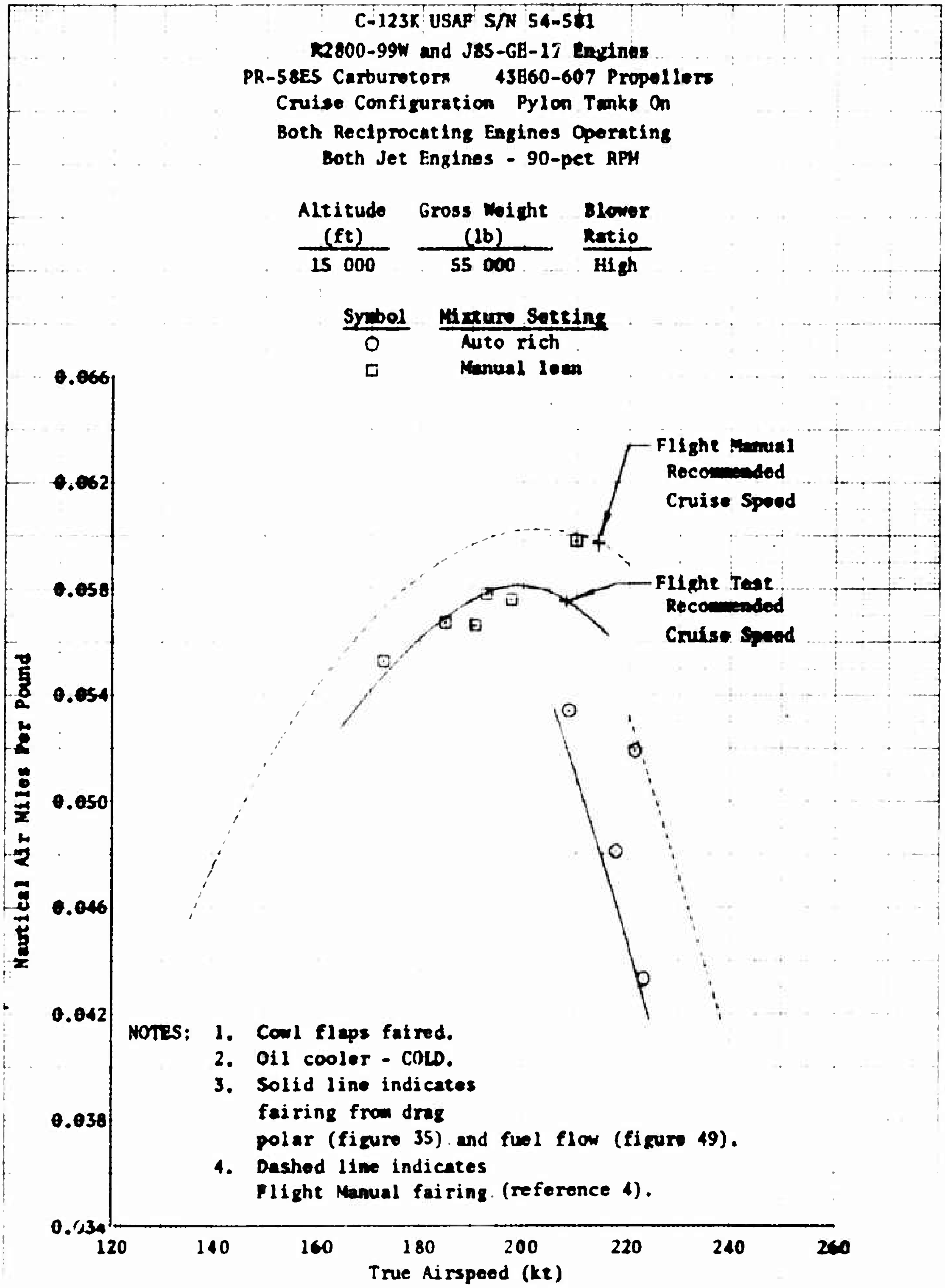


Figure 24. Specific Range

C-123K USAF S/N 54-581
R2800-99W and J85-GE-17 Engines
PR-58E5 Carburetors 43E60-607 Propellers
Power Approach Configuration
Both Reciprocating Engines Operating
Both Jet Engines - Idle
Pylon Tanks On

Altitude (ft)	Gross Weight (lb)	Blower Ratio
5000	45 000	Low

Symbol	Mixture Setting
○	Auto rich

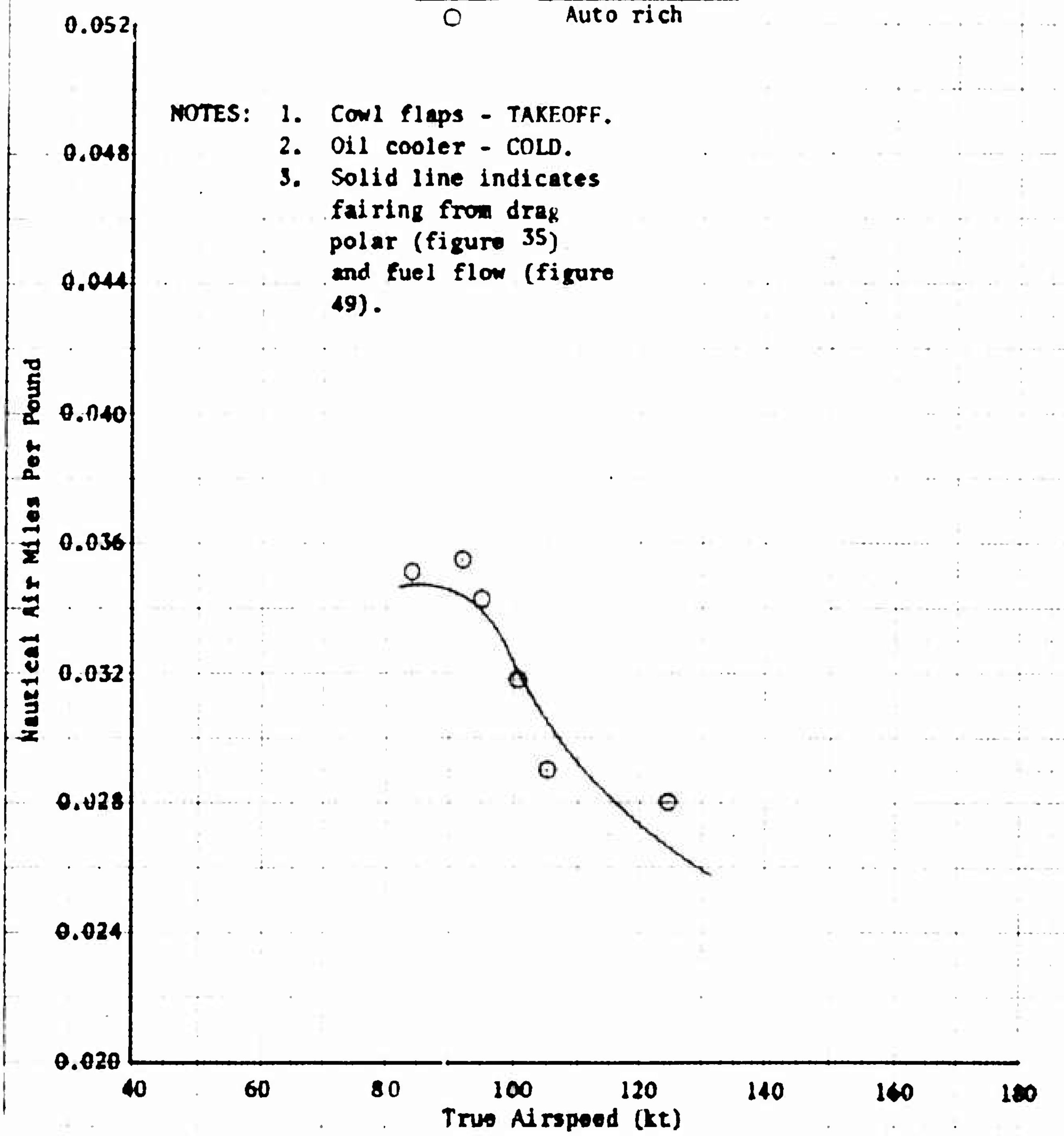


Figure 25. Specific Range

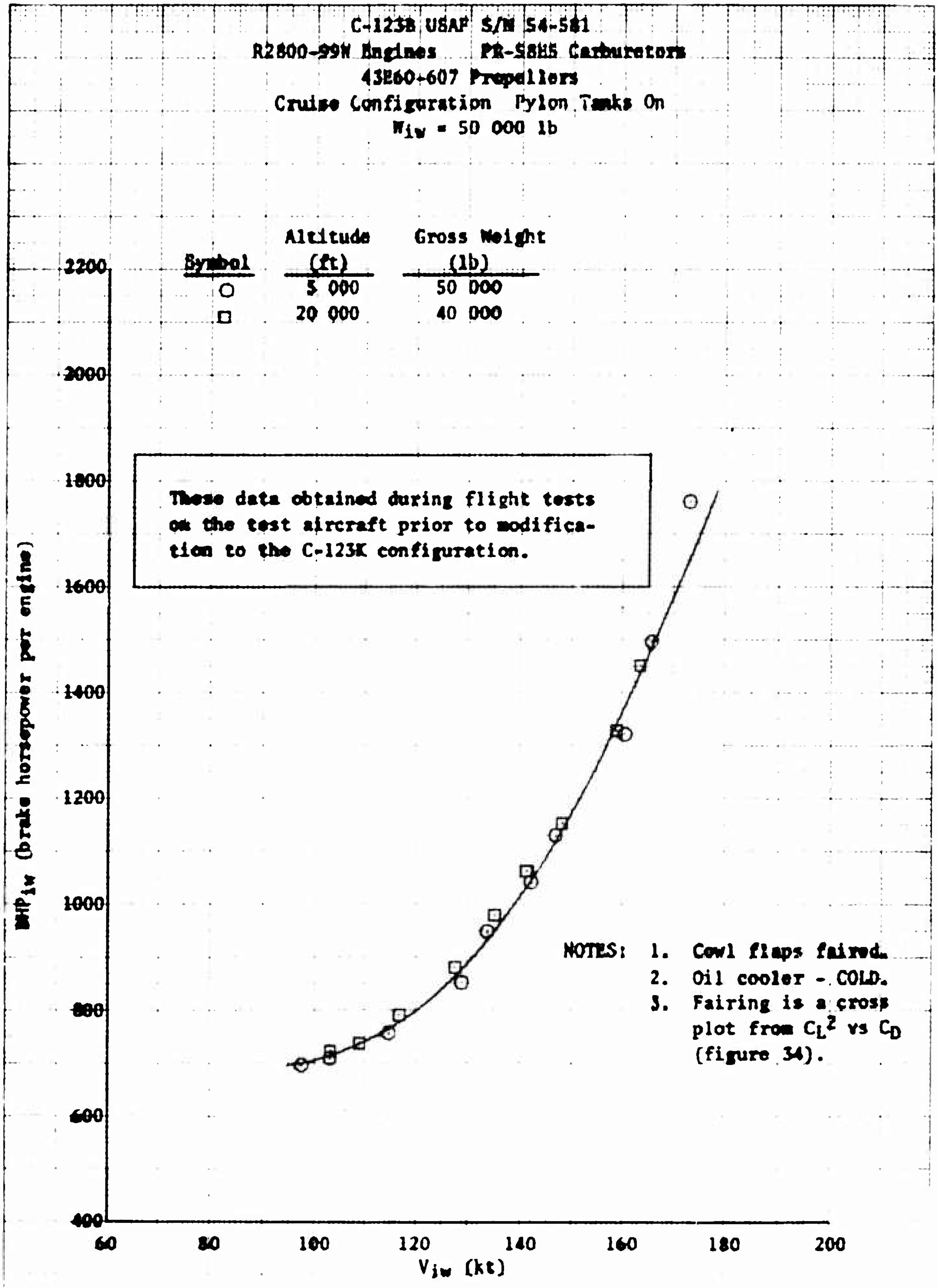


Figure 26. Level Flight Performance

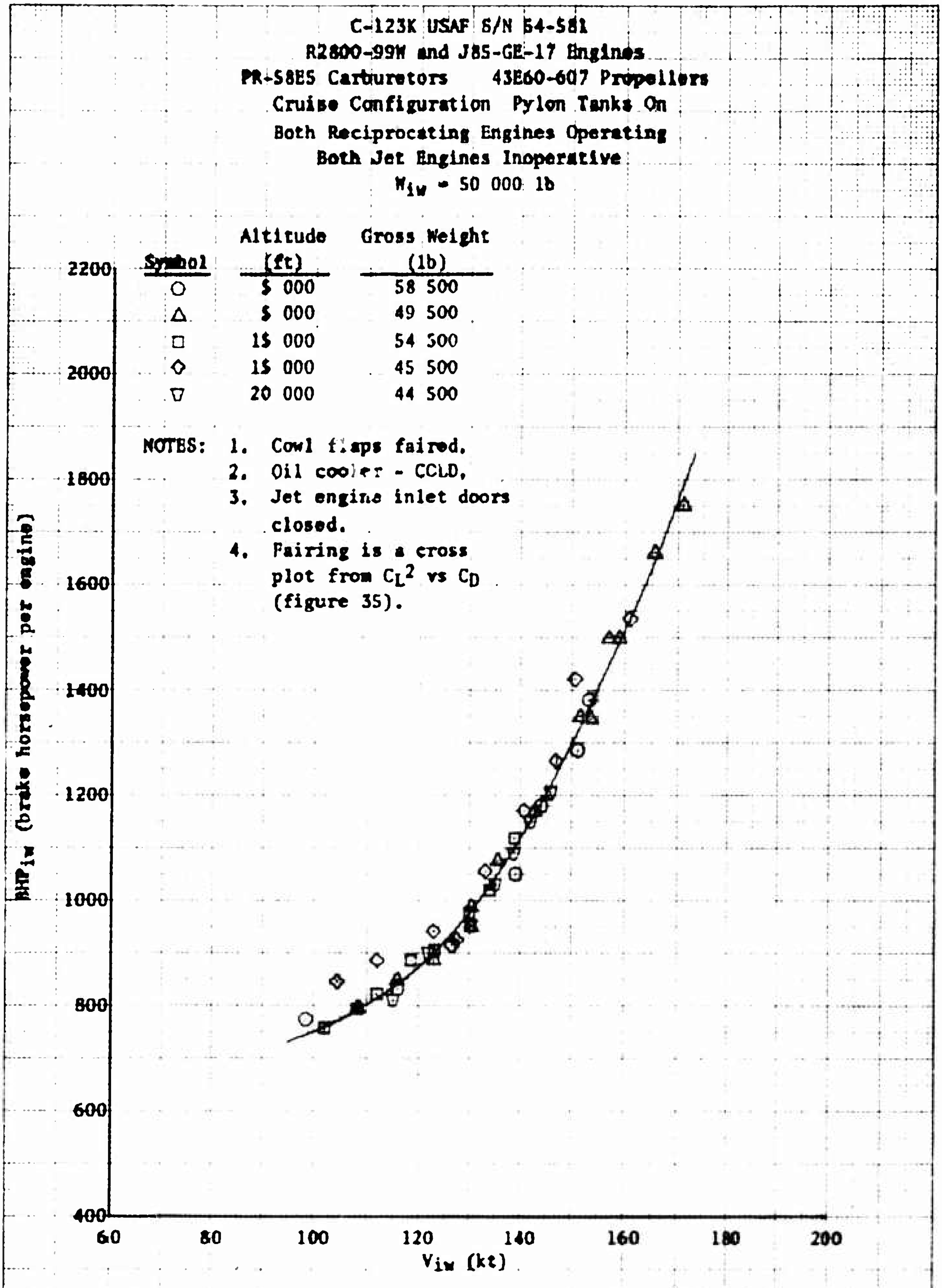


Figure 27. Level Flight Performance

C-123K USAF S/N 54-581
R2800-99W and J85-GE-17 Engines
PR-58ES Carburetors 43E60-607 Propellers
Cruise Configuration Pylon Tanks On
Both Reciprocating Engines Operating
Both Jet Engines - 90-pct RPM
W_{iw} = 50 000 lb

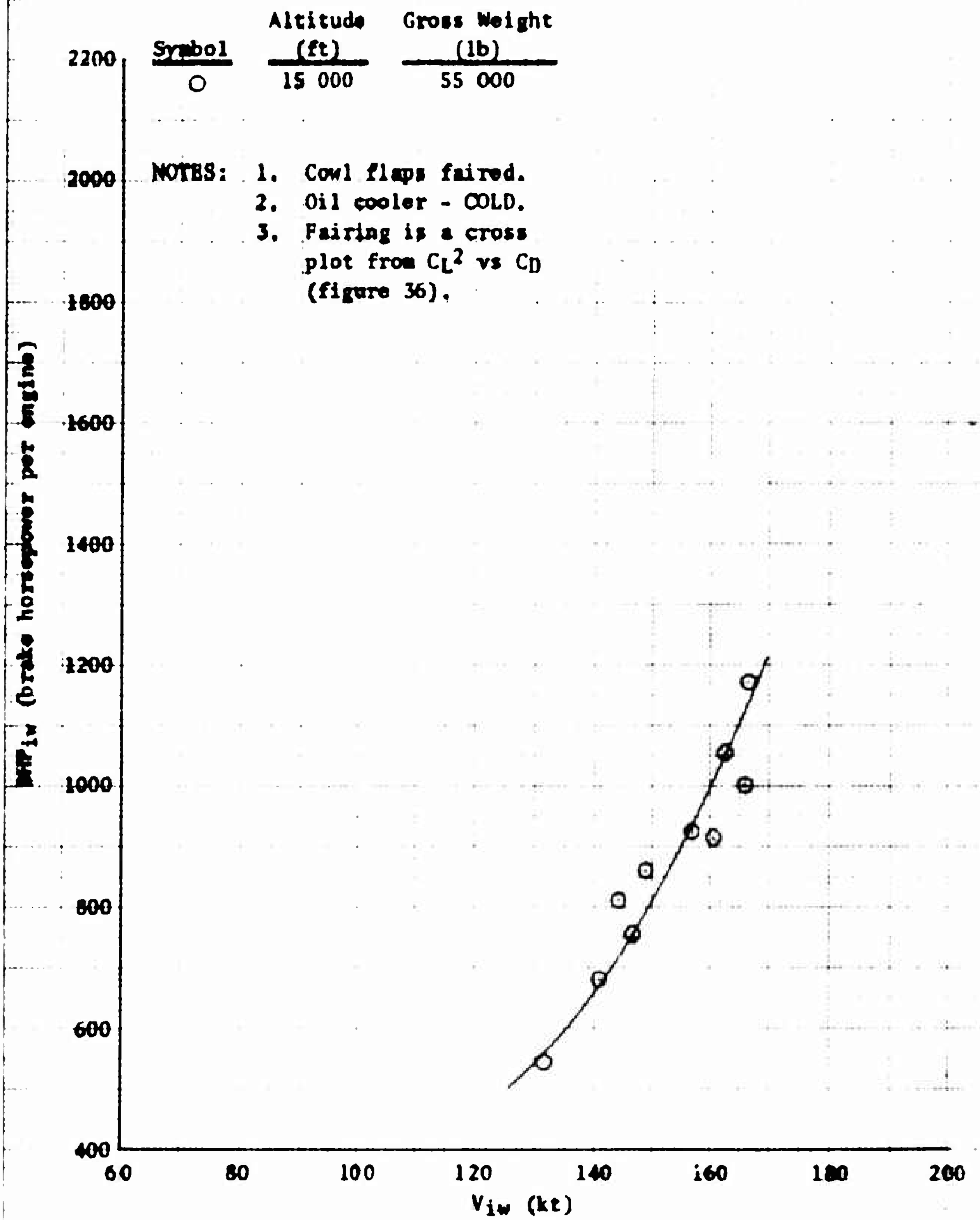


Figure 28. Level Flight Performance

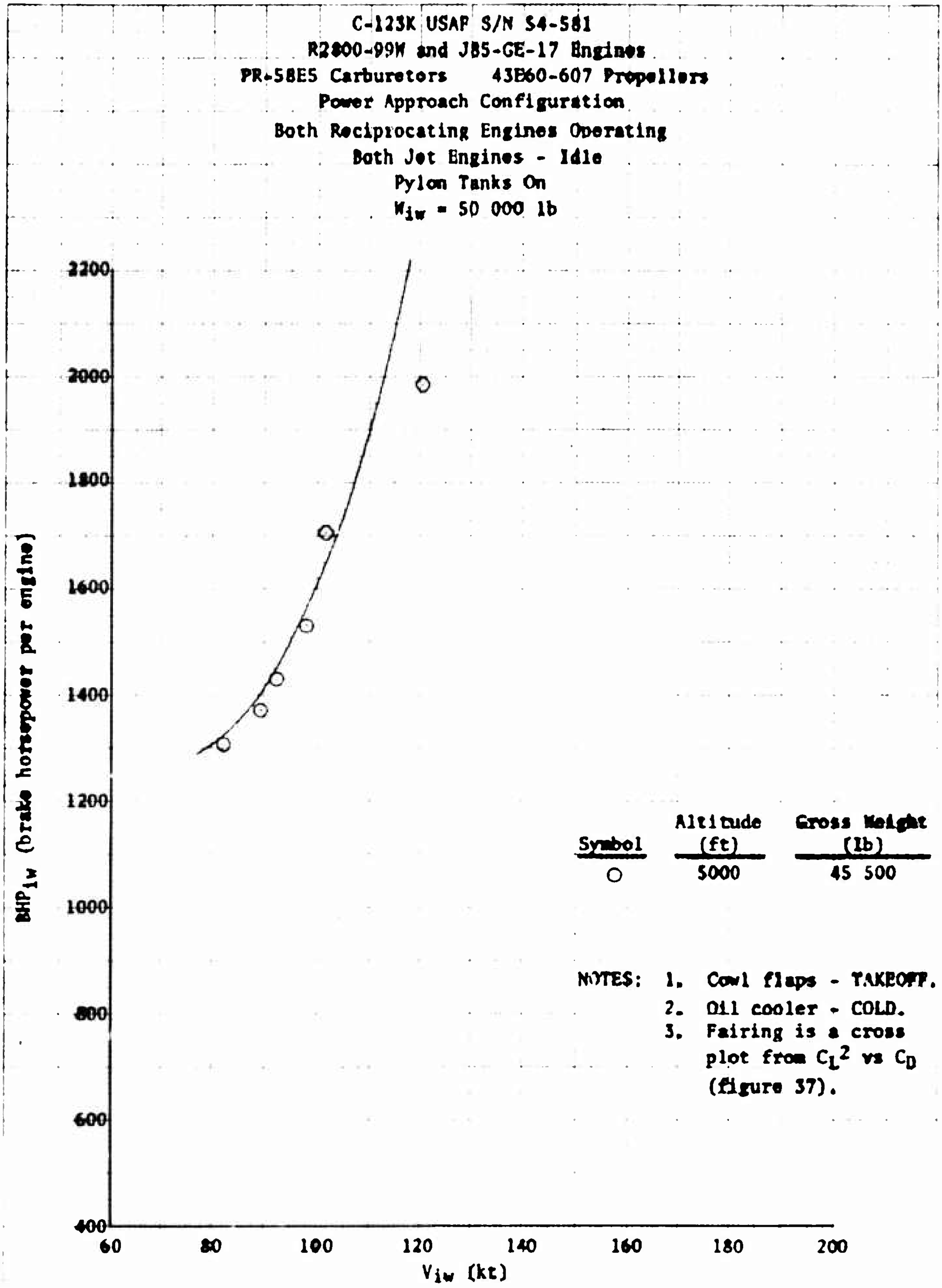


Figure 29. Level Flight Performance

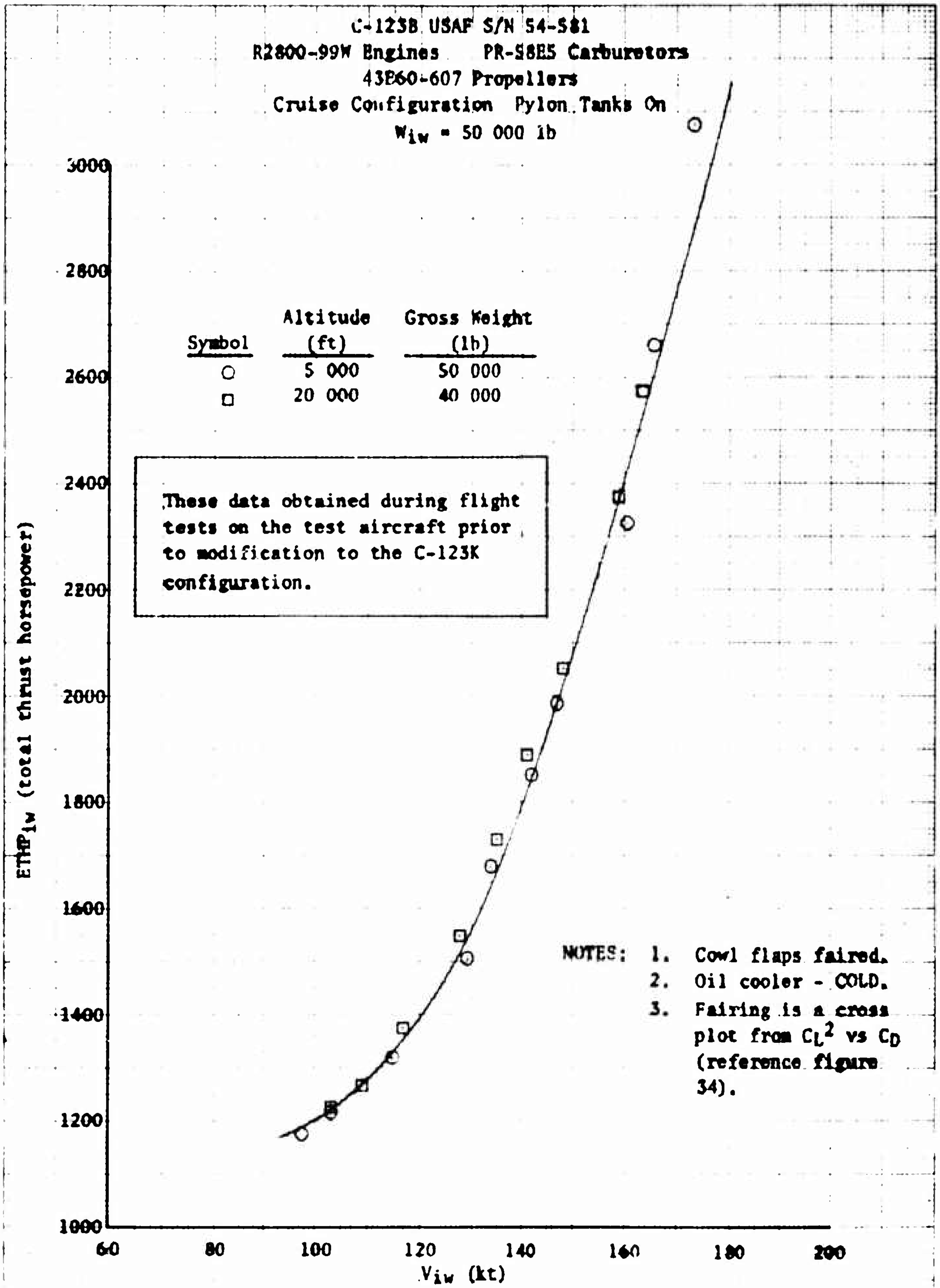


Figure 30. Level Flight Performance

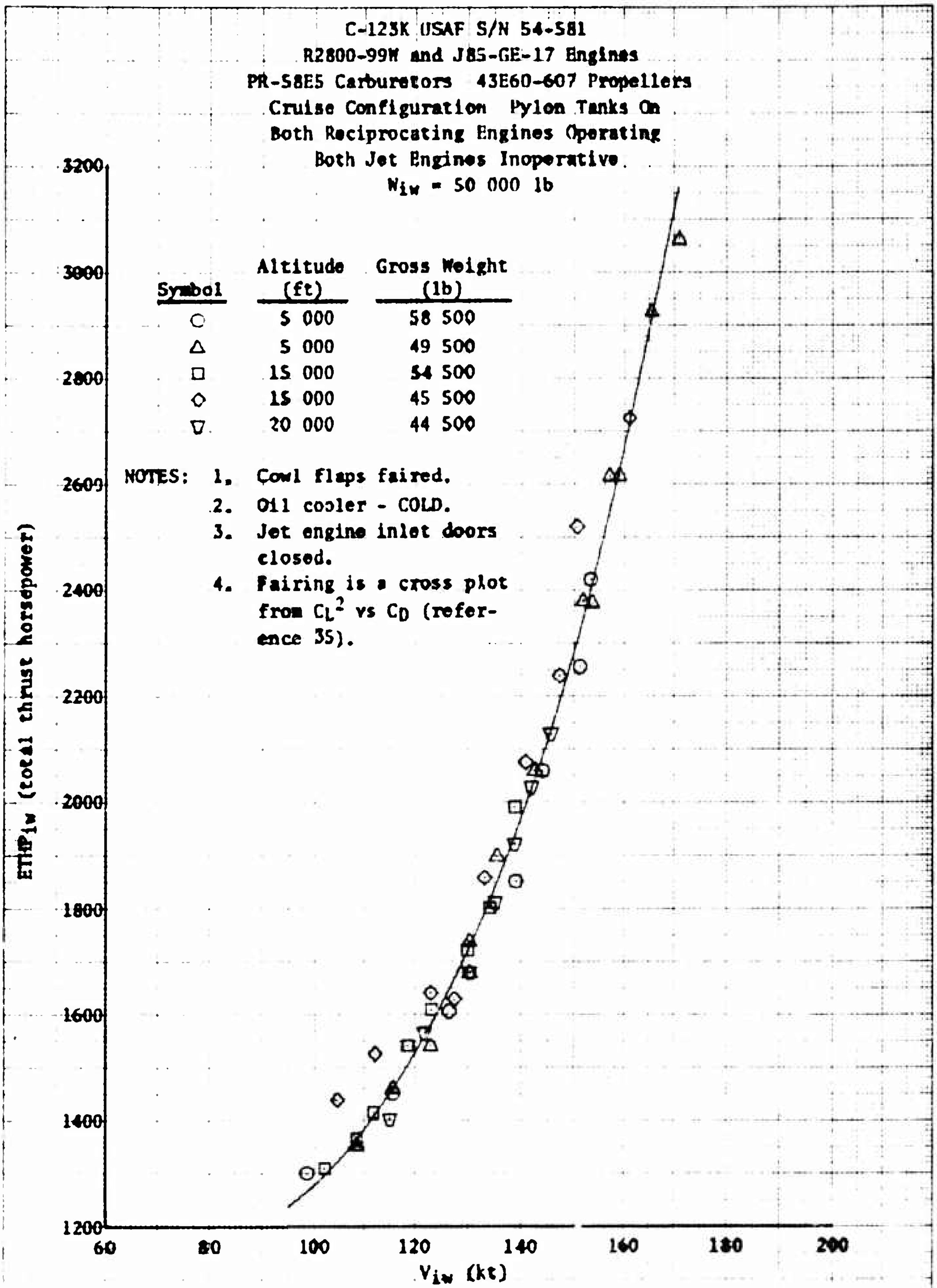


Figure 31. Level Flight Performance

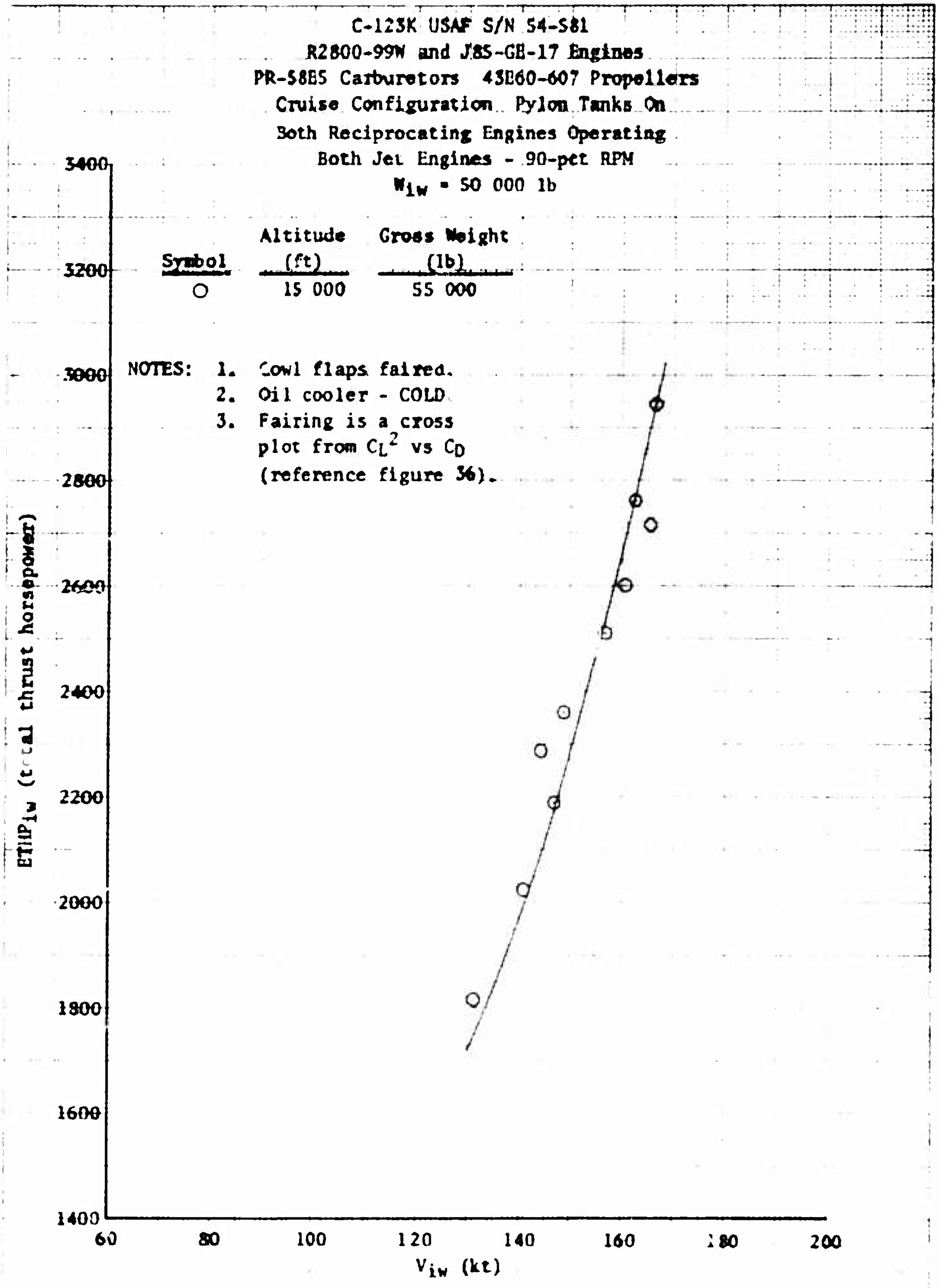


Figure 32. Level Flight Performance

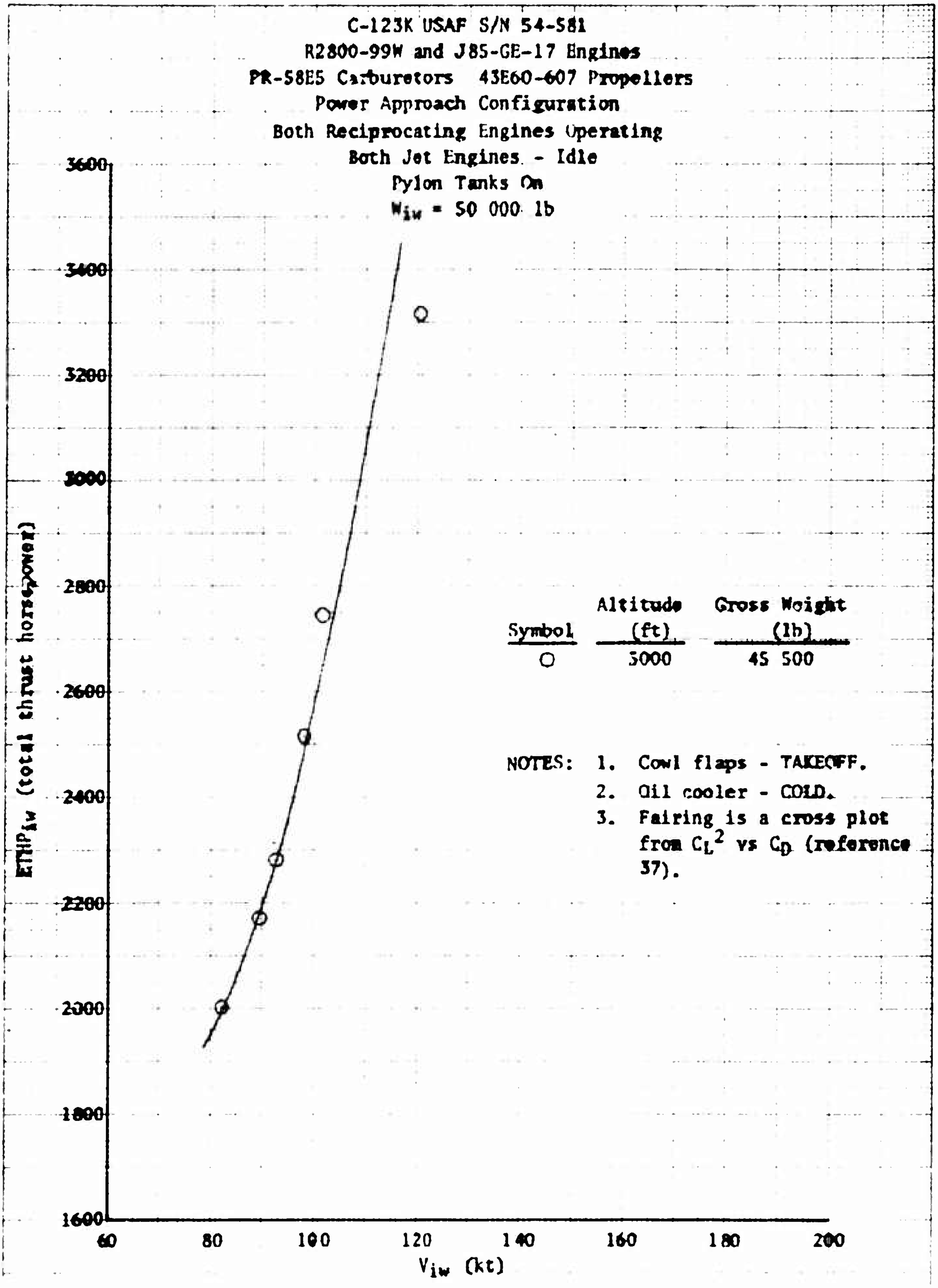


Figure 33. Level Flight Performance

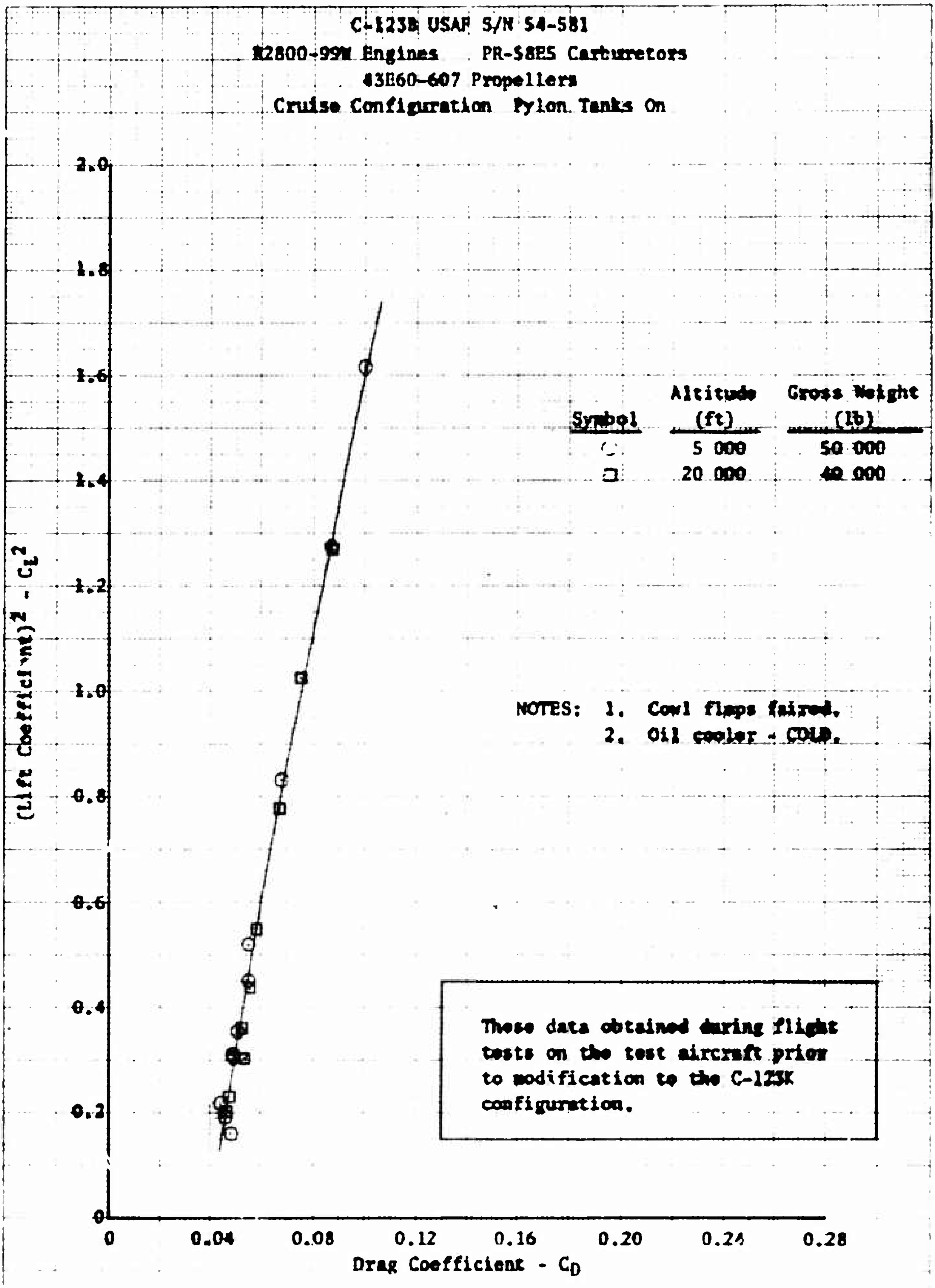


Figure 54. Drag Polar

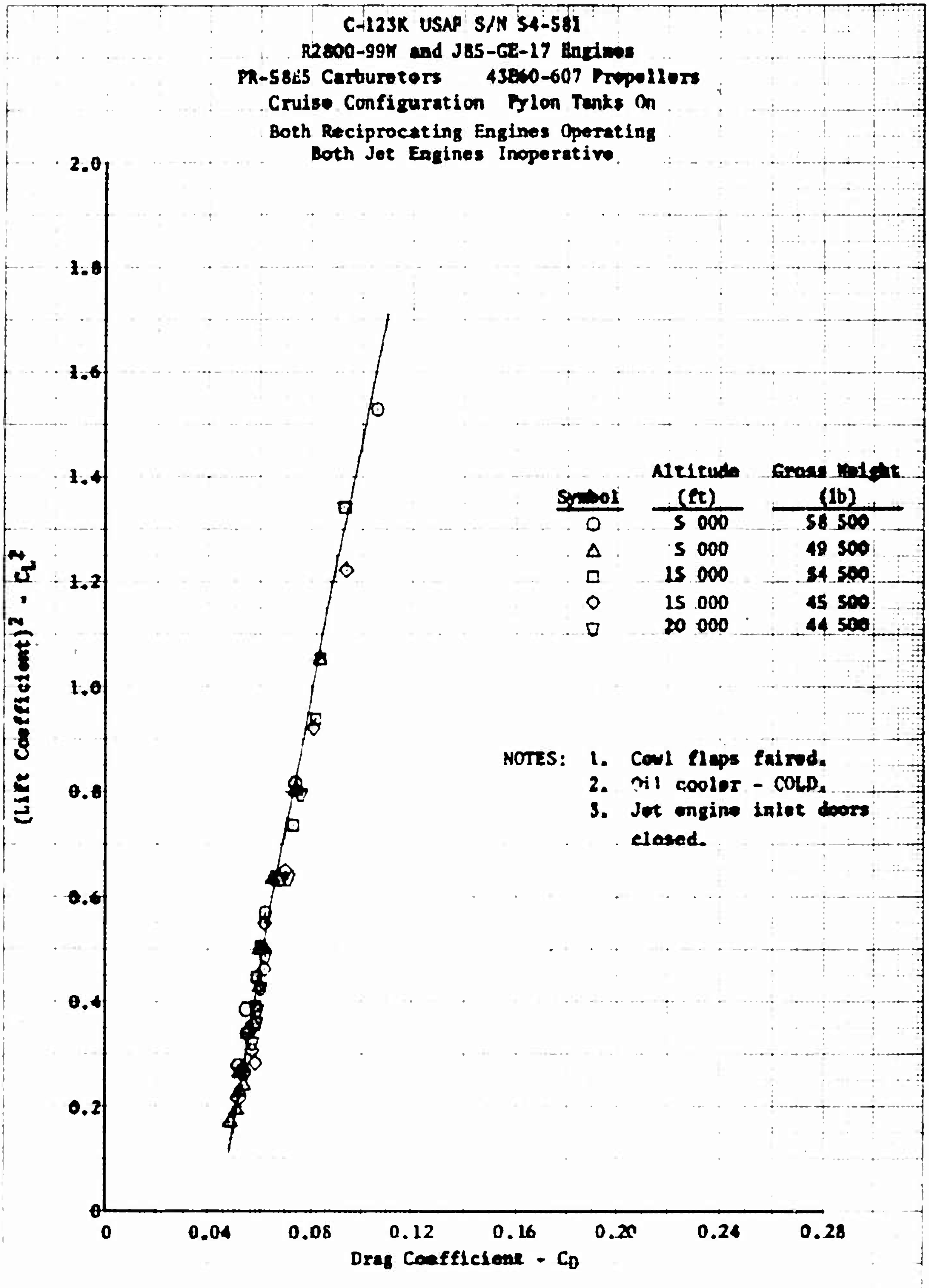


Figure 56. Drag Polar

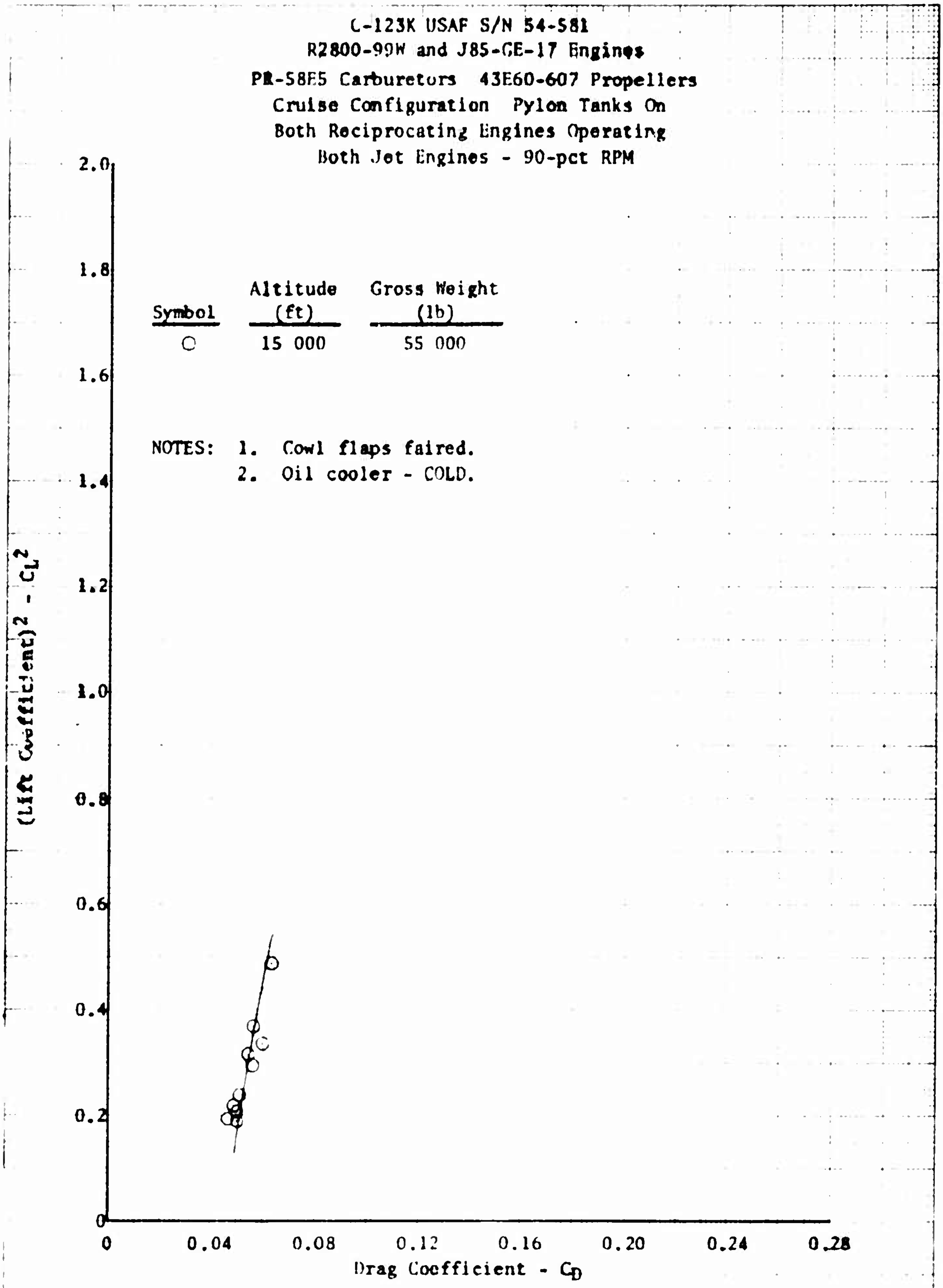


Figure 36. Drag Polar

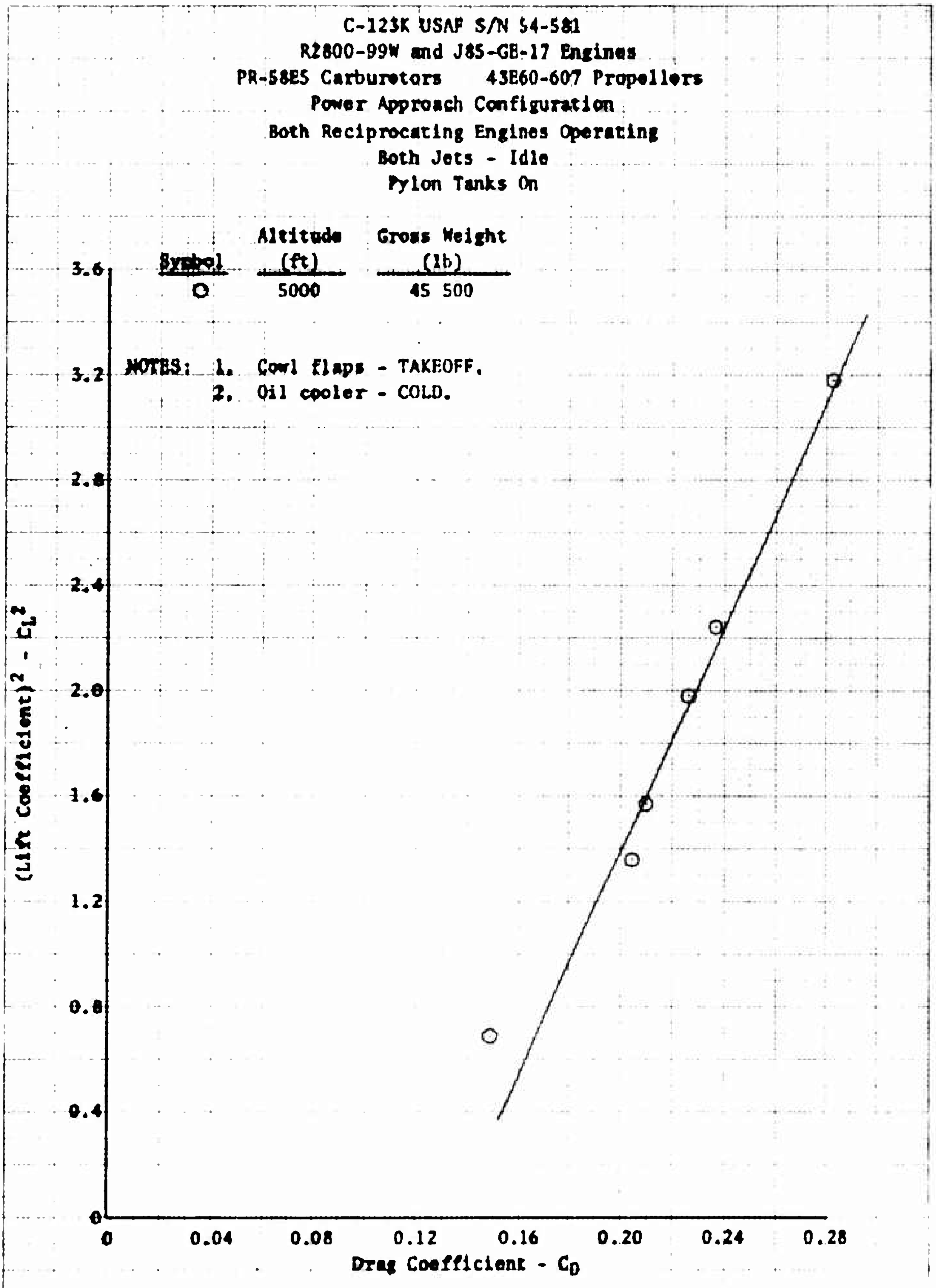


Figure 37. Drag Polar

C-123K USAF S/N 54-581
R2800-99W and J85-GE-17 Engines
PR-58E5 Carburetors   43E60-607 Propellers
Sea Level, Standard Day, No Wind
Forward cg (20.6-pct MAC) Full Flaps (60 deg)
Maximum Braking and Reverse Thrust - Antiskid On

Symbol	Average Gross Weight (lb)	Reciprocating Engine Power	Jet Engine Power
○	58 950	zero thrust	idle
□	58 700	zero thrust	inoperative
△	43 950	idle	idle

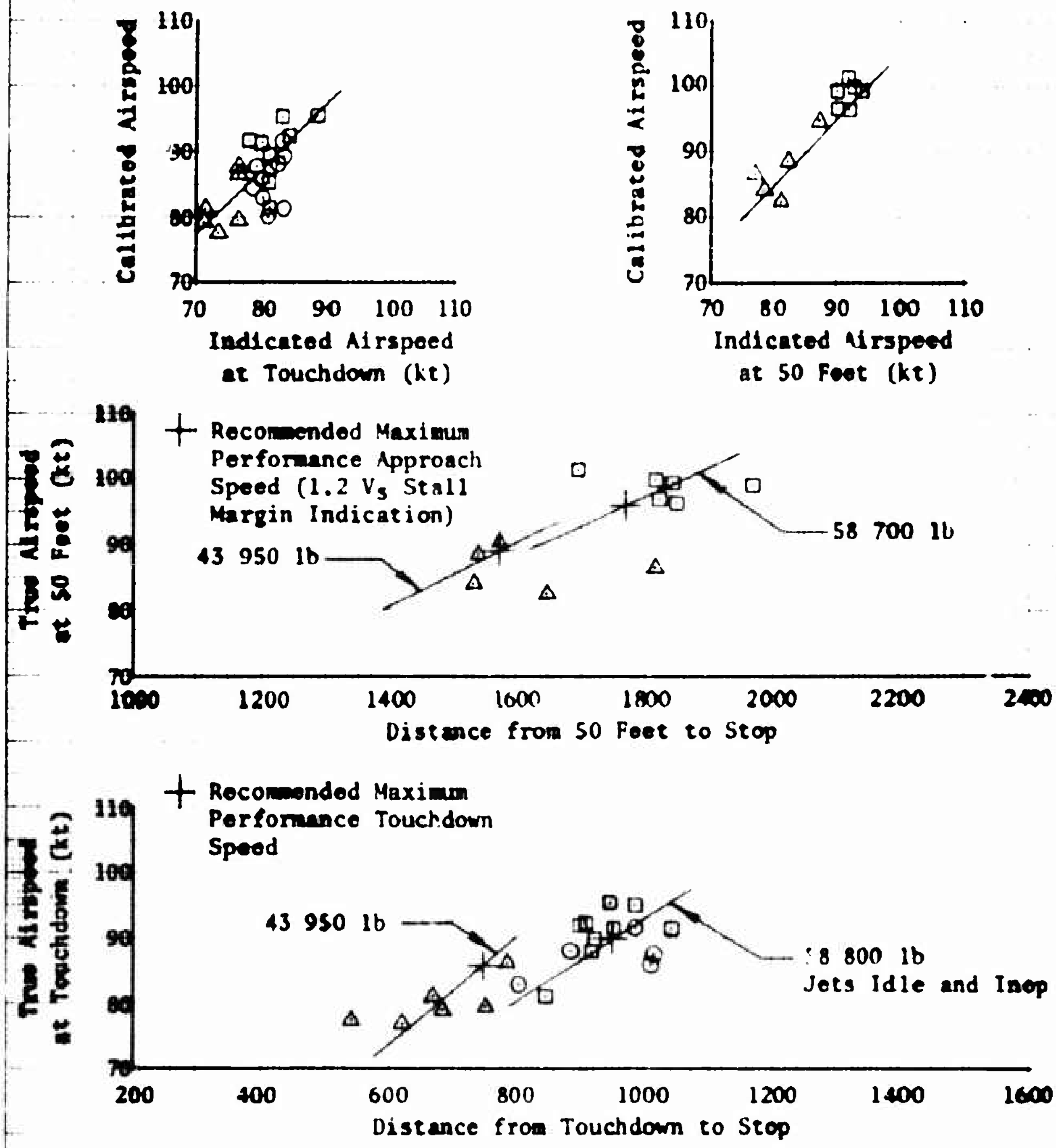


Figure 38. Landing Performance

C-123K USAF S/N 54-581
R2800-99W and J85-GE-17 Engines
PR-58E5 Carburetors   43E60-607 Propellers
Sea Level, Standard Day, No Wind
Forward cg (20.6-pct MAC) Full Flaps (60 deg)
Maximum Braking - Antiskid On

Symbol	Average Gross Weight (lb)	Reciprocating Engine Power	Jet Engine Power
○	59 200	zero thrust	idle
□	46 400	zero thrust	idle

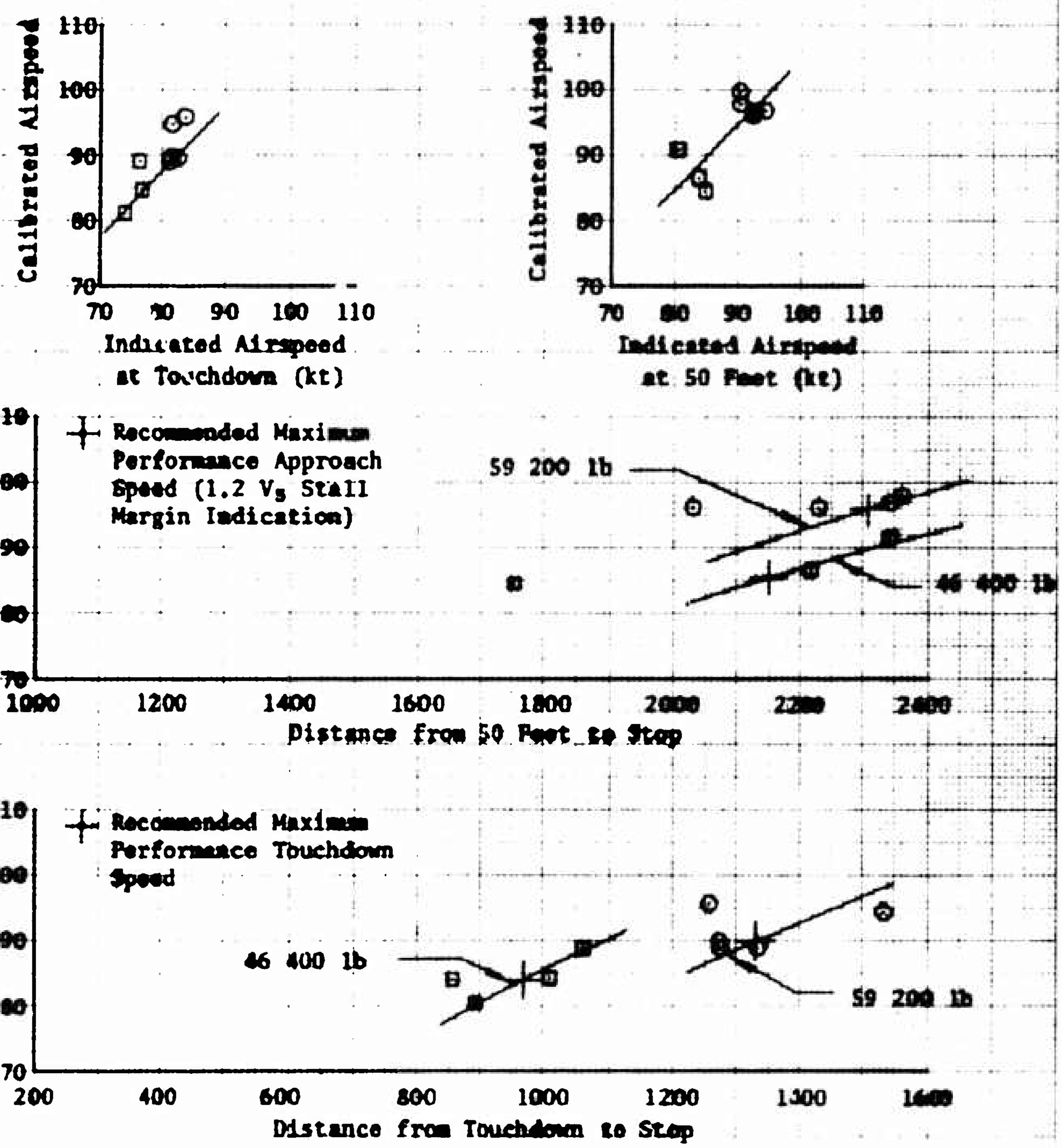


Figure 39. Landing Performance

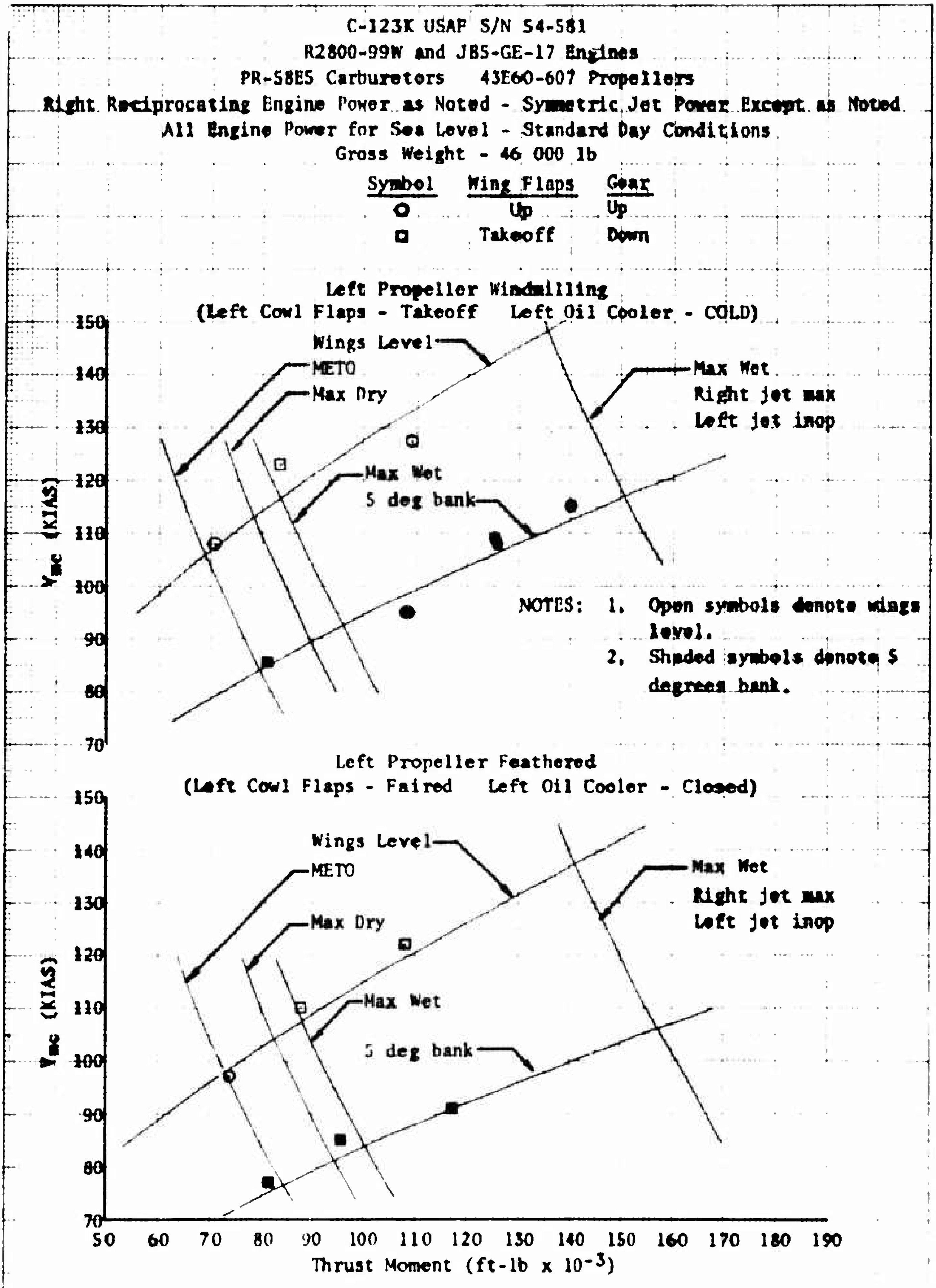


Figure 40. Air Minimum Control Speeds (Full Right Rudder)

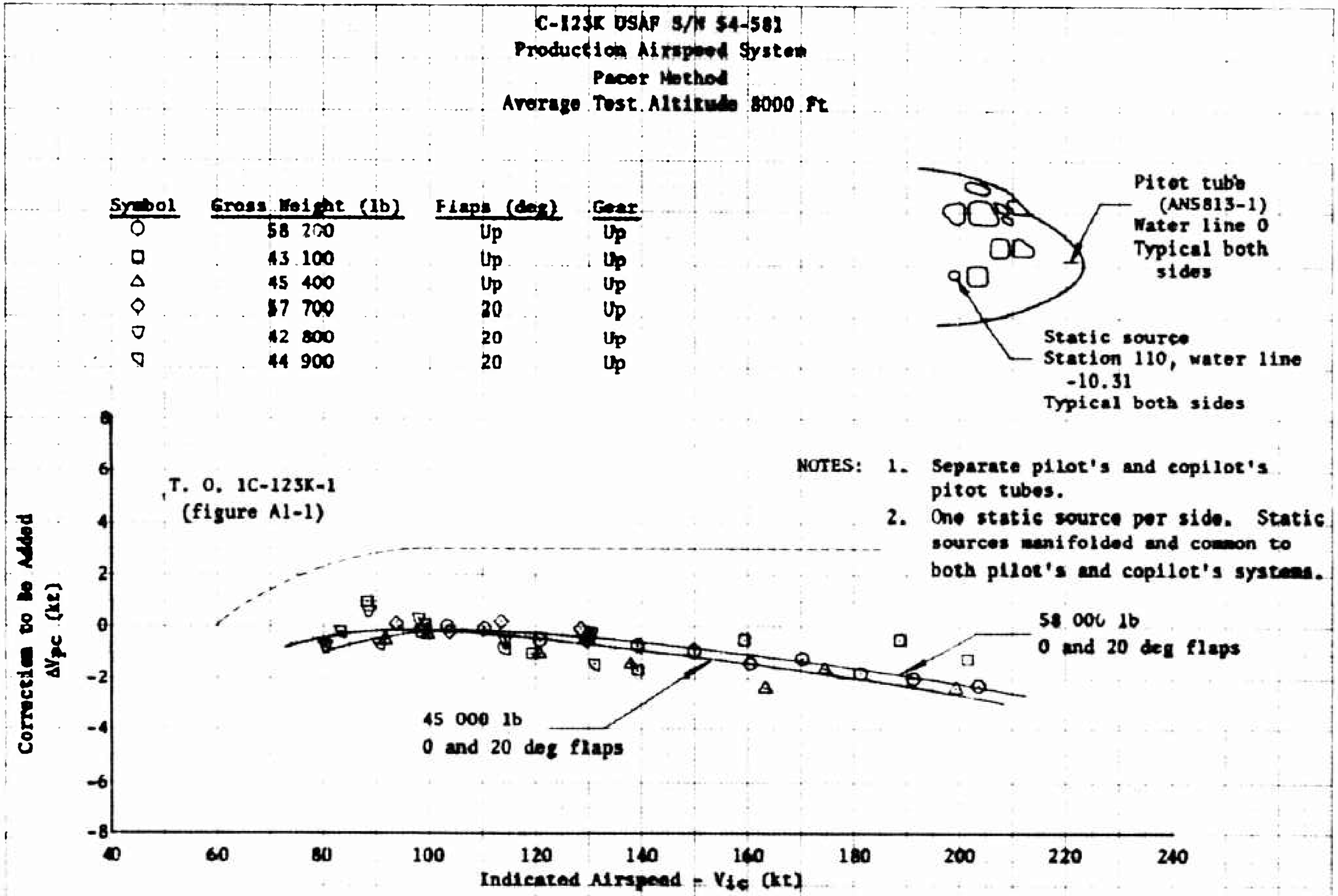


Figure 41. Airspeed Calibration

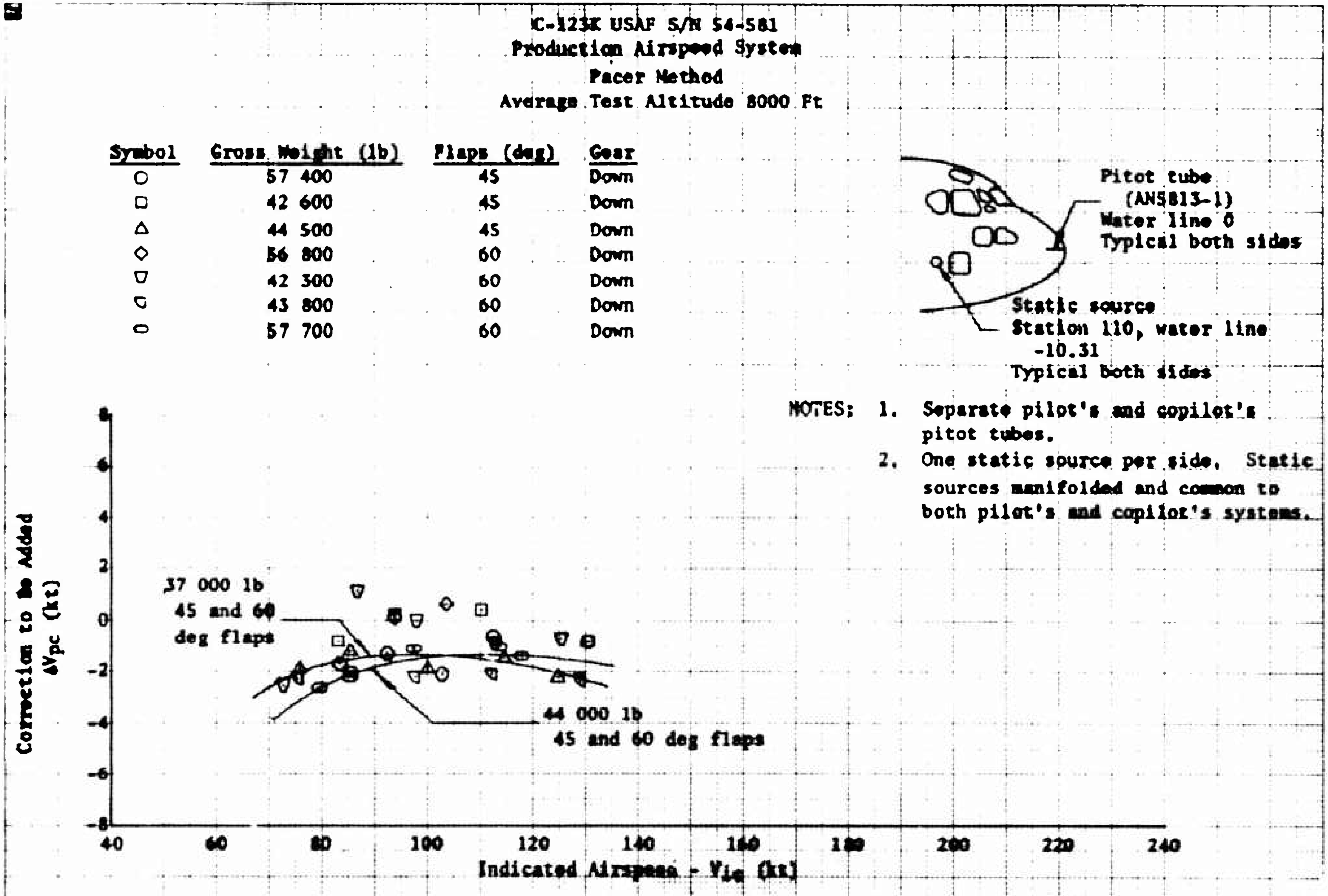


Figure 41. Airspeed Calibration

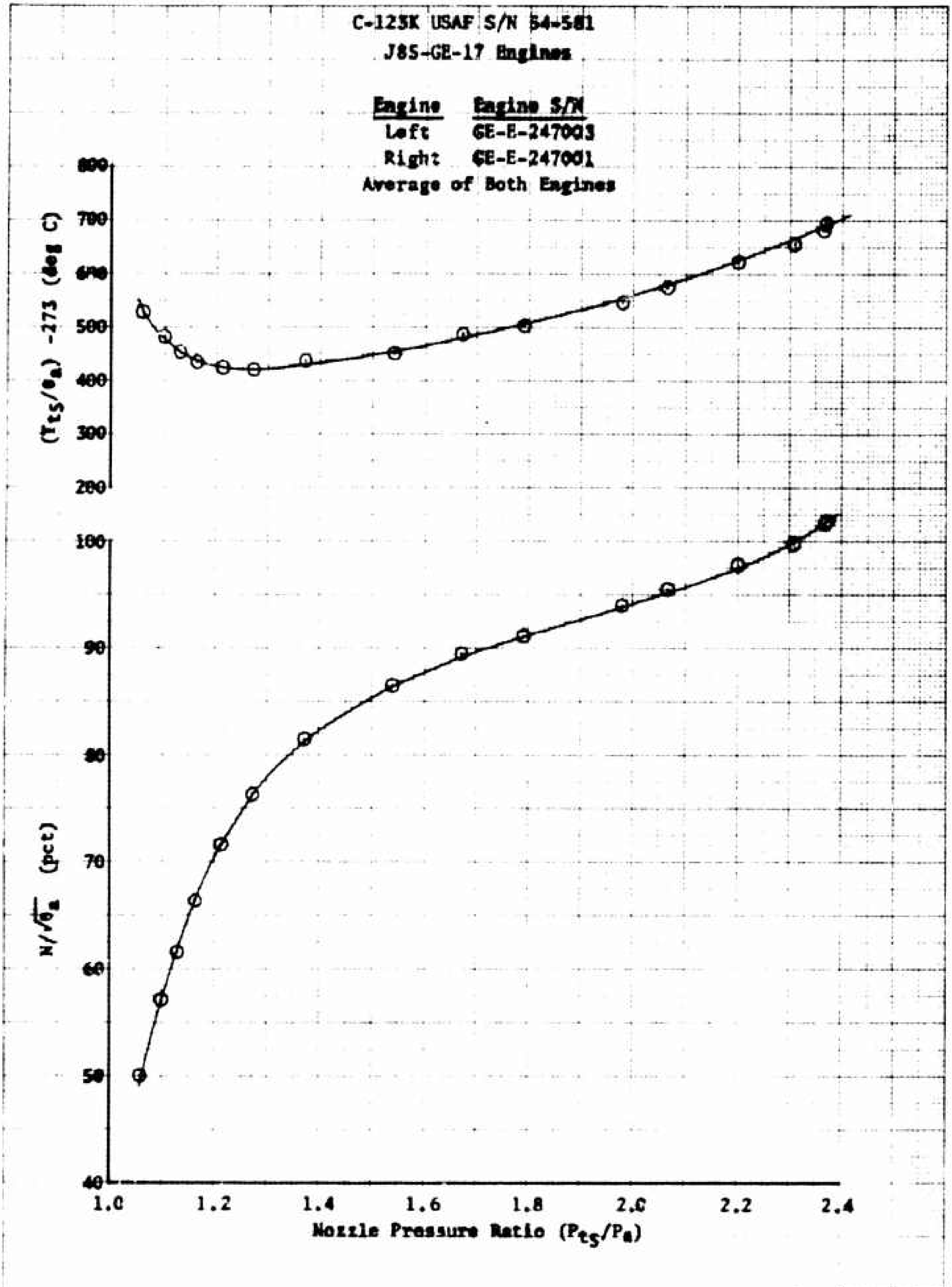


Figure 43. Installed Engine Performance

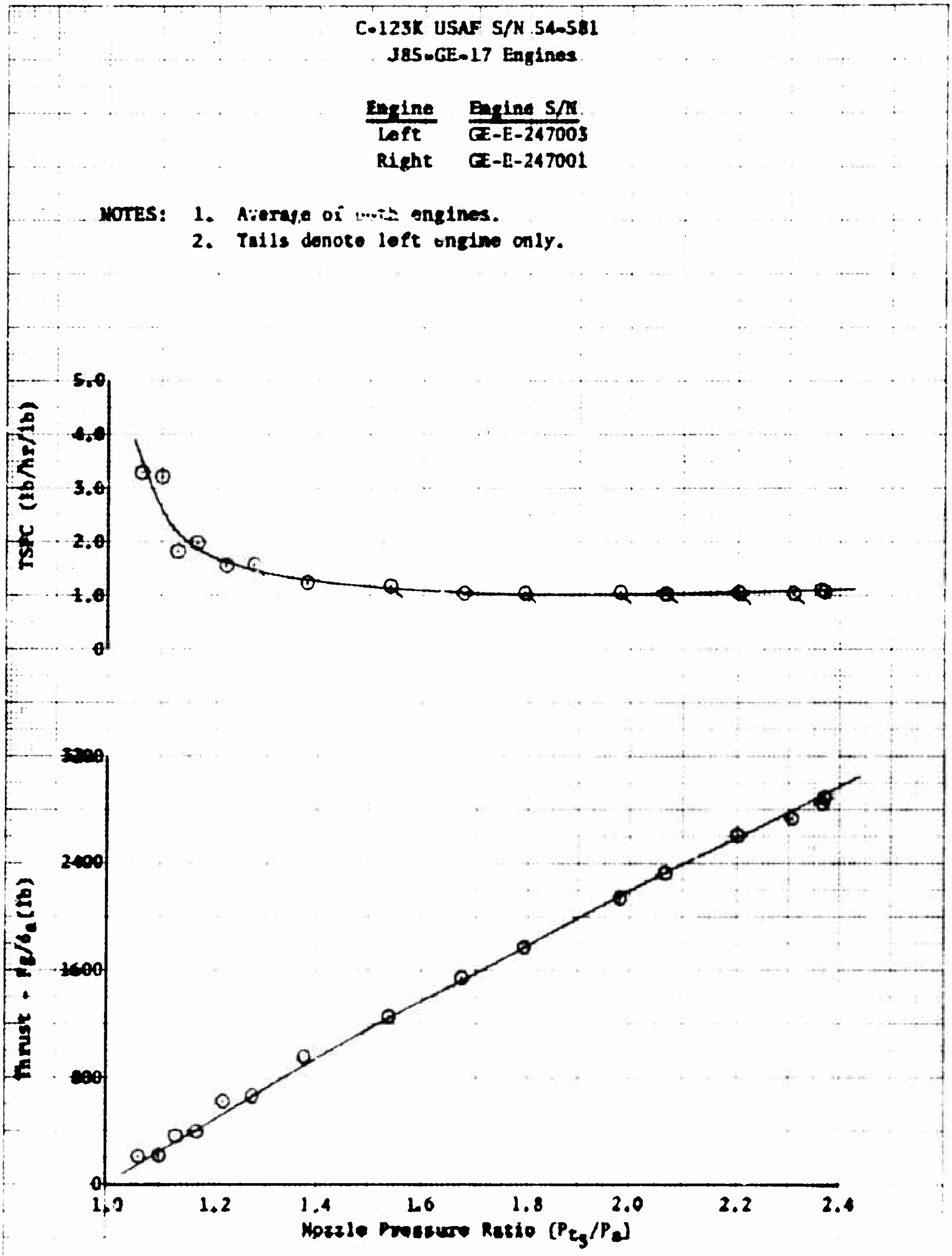


Figure 44. Installed Engine Performance

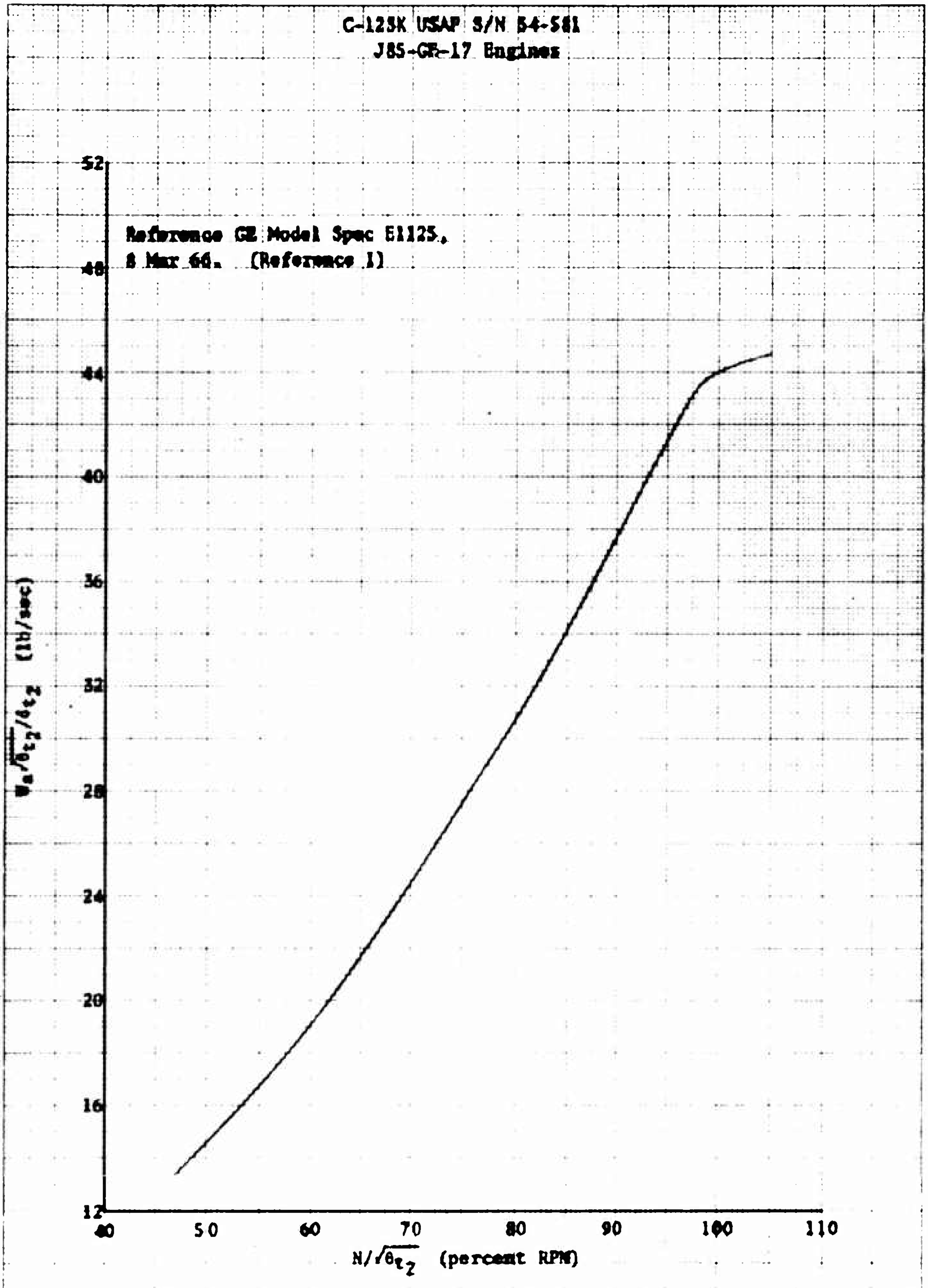


Figure 46. Corrected Airflow vs Corrected Engine Speed

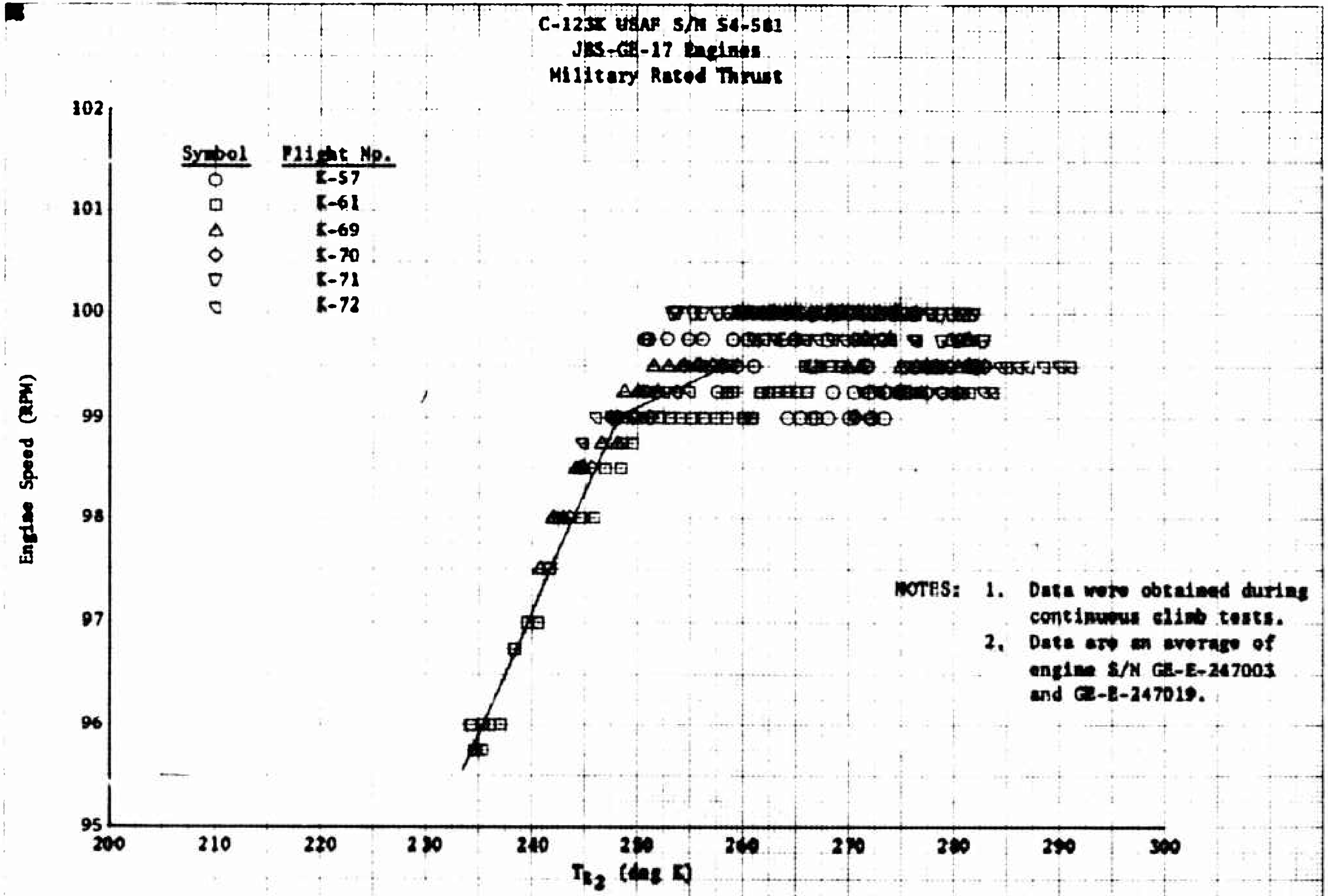


Figure 46. Engine Bias Curve

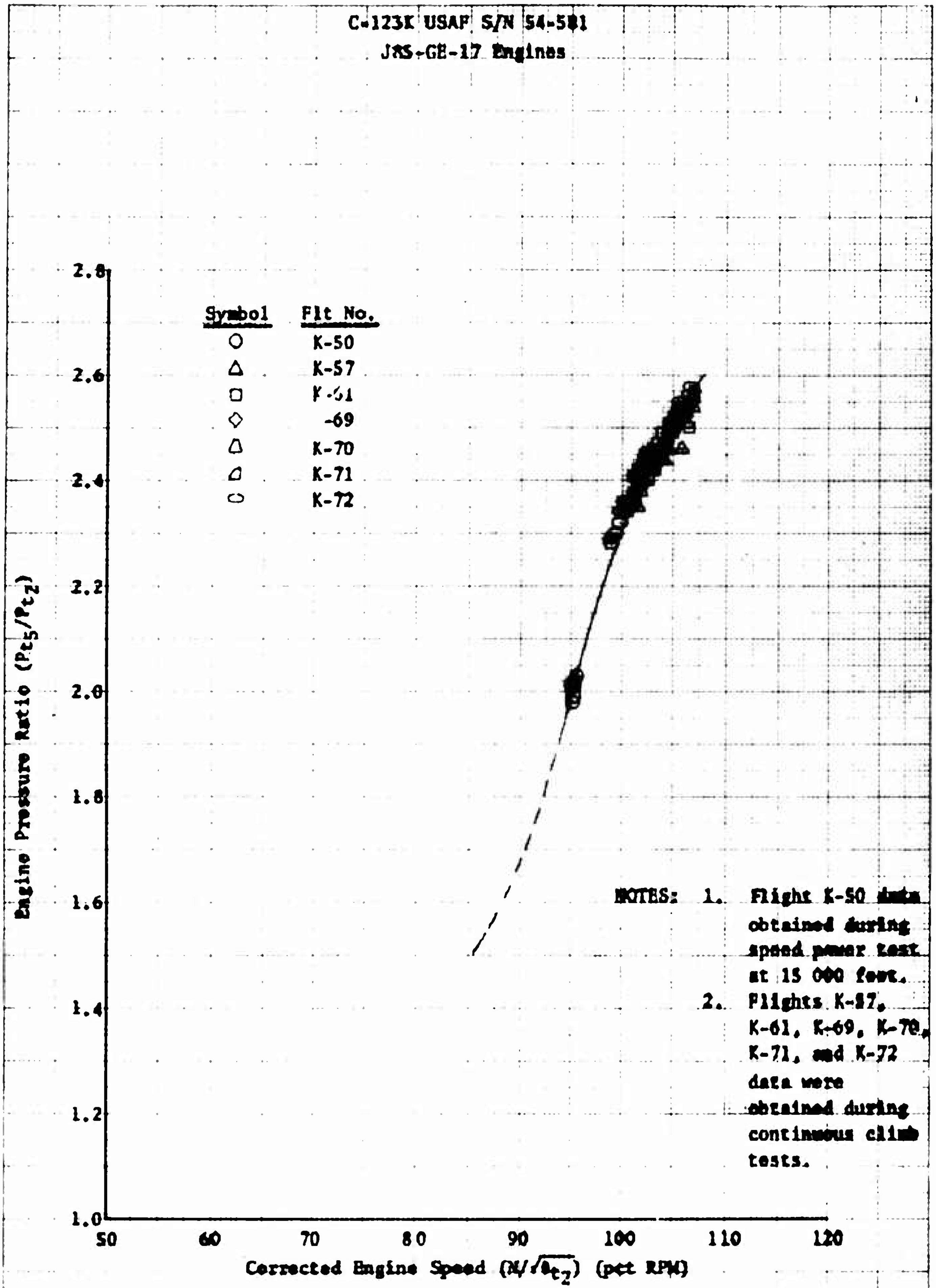


Figure 47. Engine Pressure Ratio vs Corrected Engine Speed

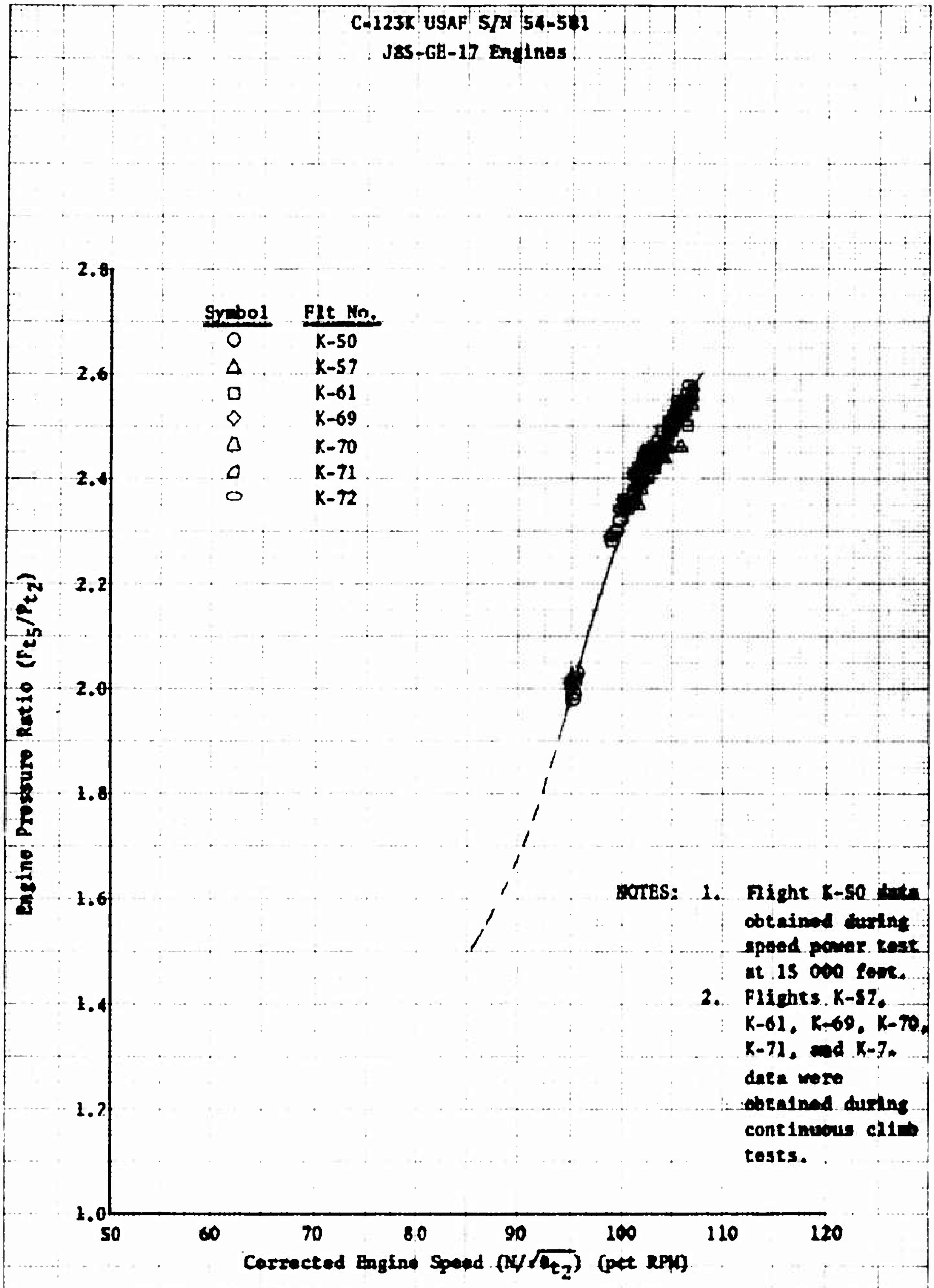


Figure 47. Engine Pressure Ratio vs Corrected Engine Speed

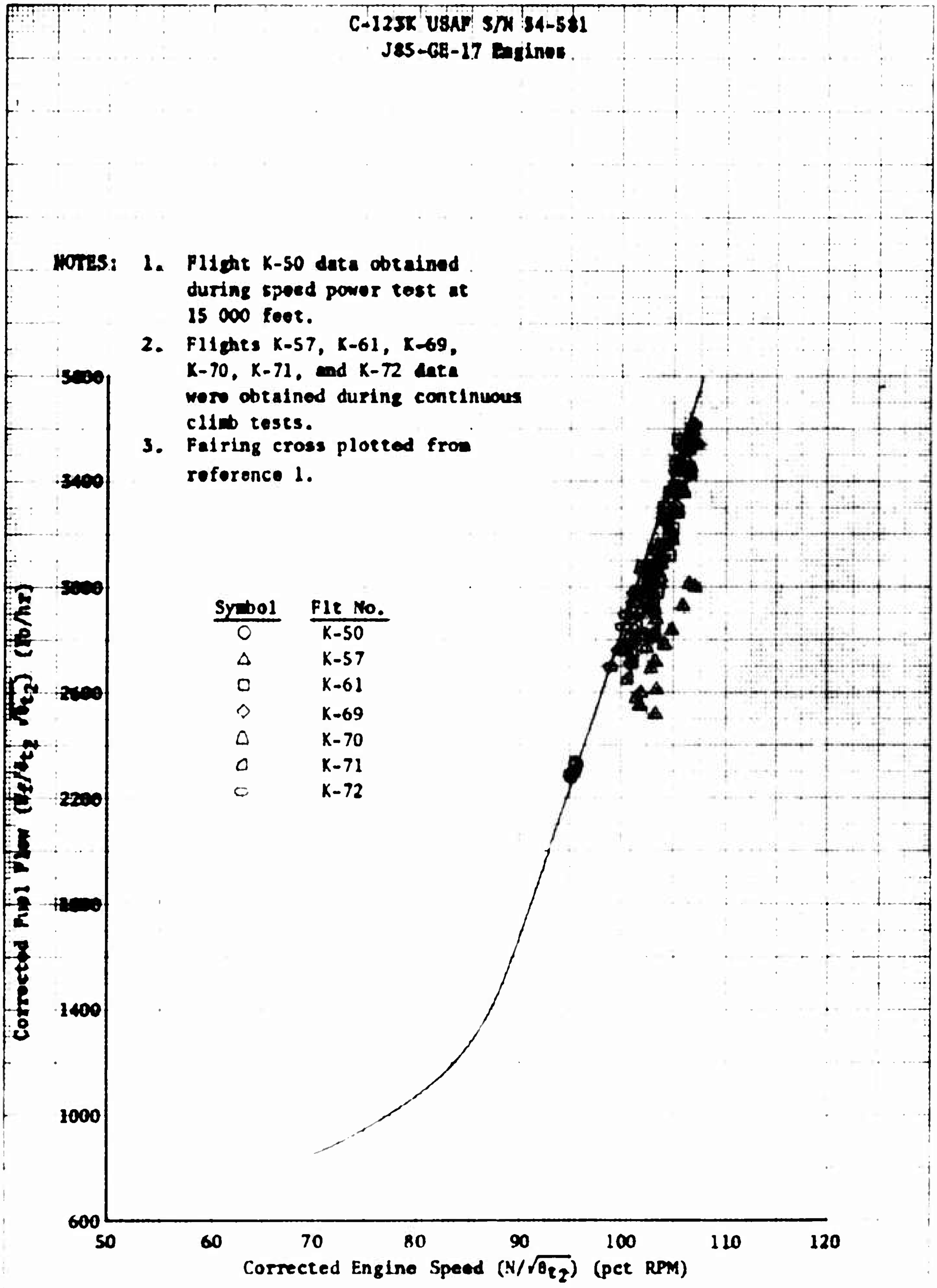


Figure 48. Corrected Fuel Flow vs Corrected Engine Speed

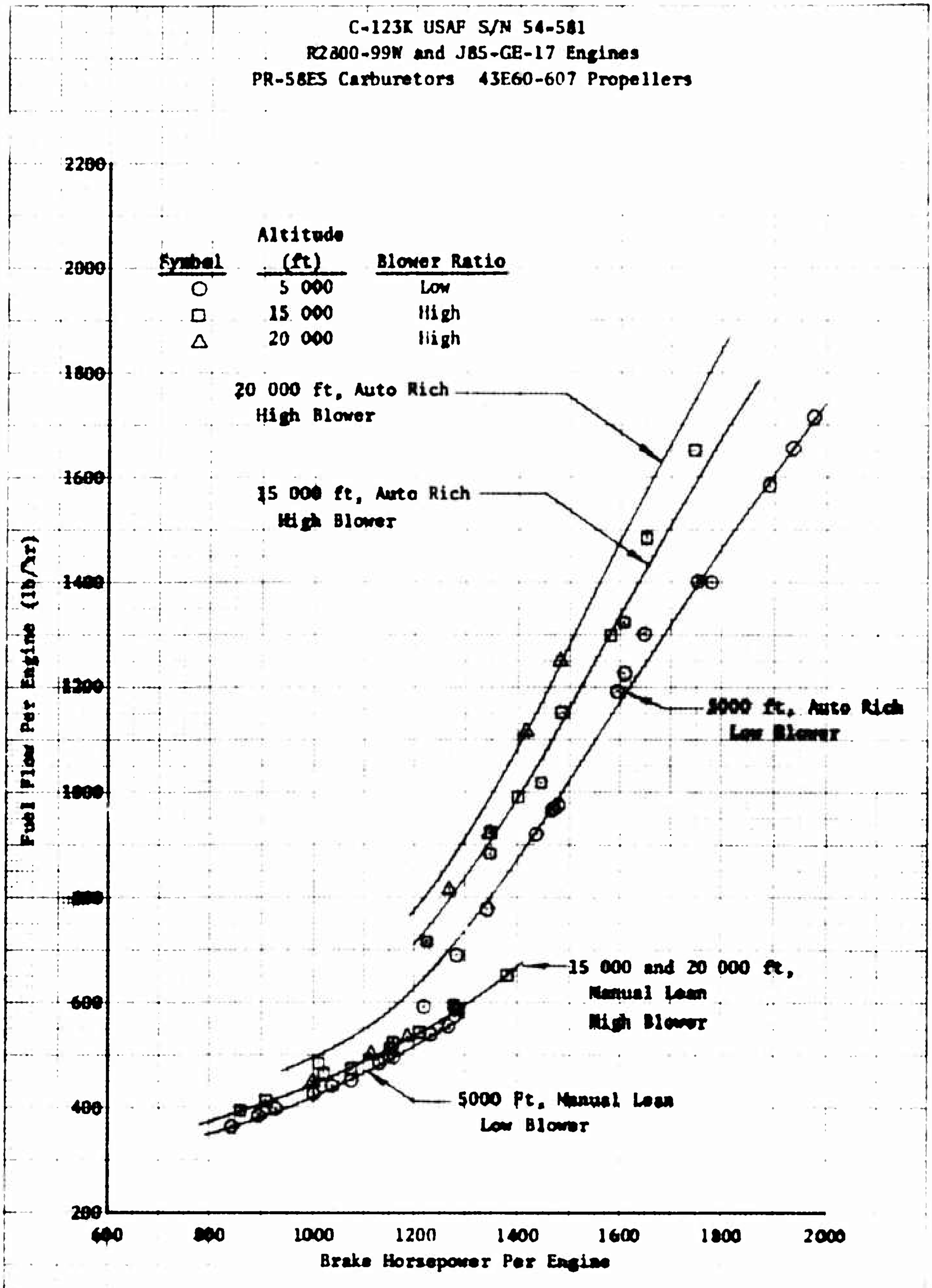


Figure 49. Reciprocating Engine Fuel Flow vs BHP

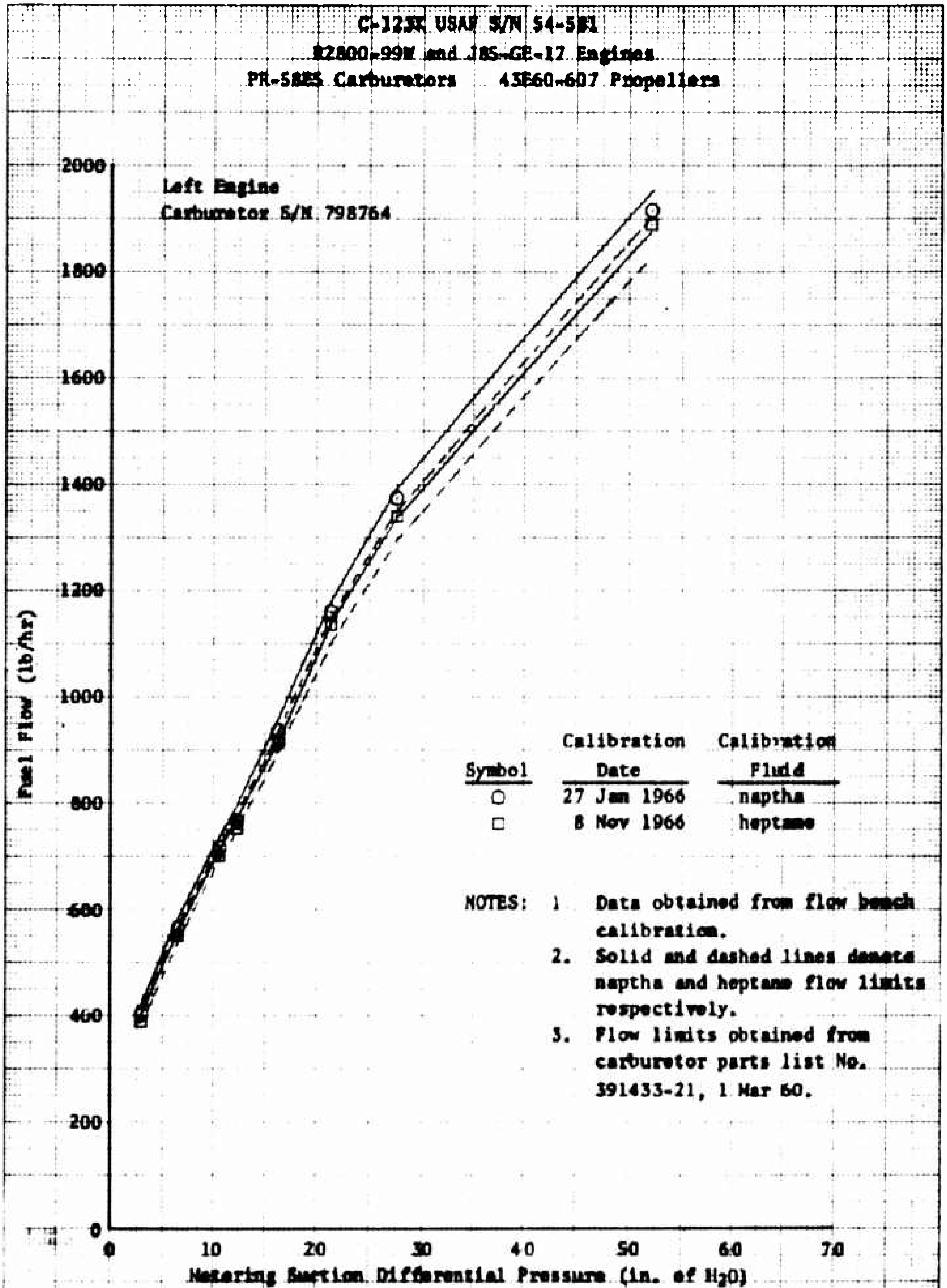


Figure 50. Carburetor Calibration

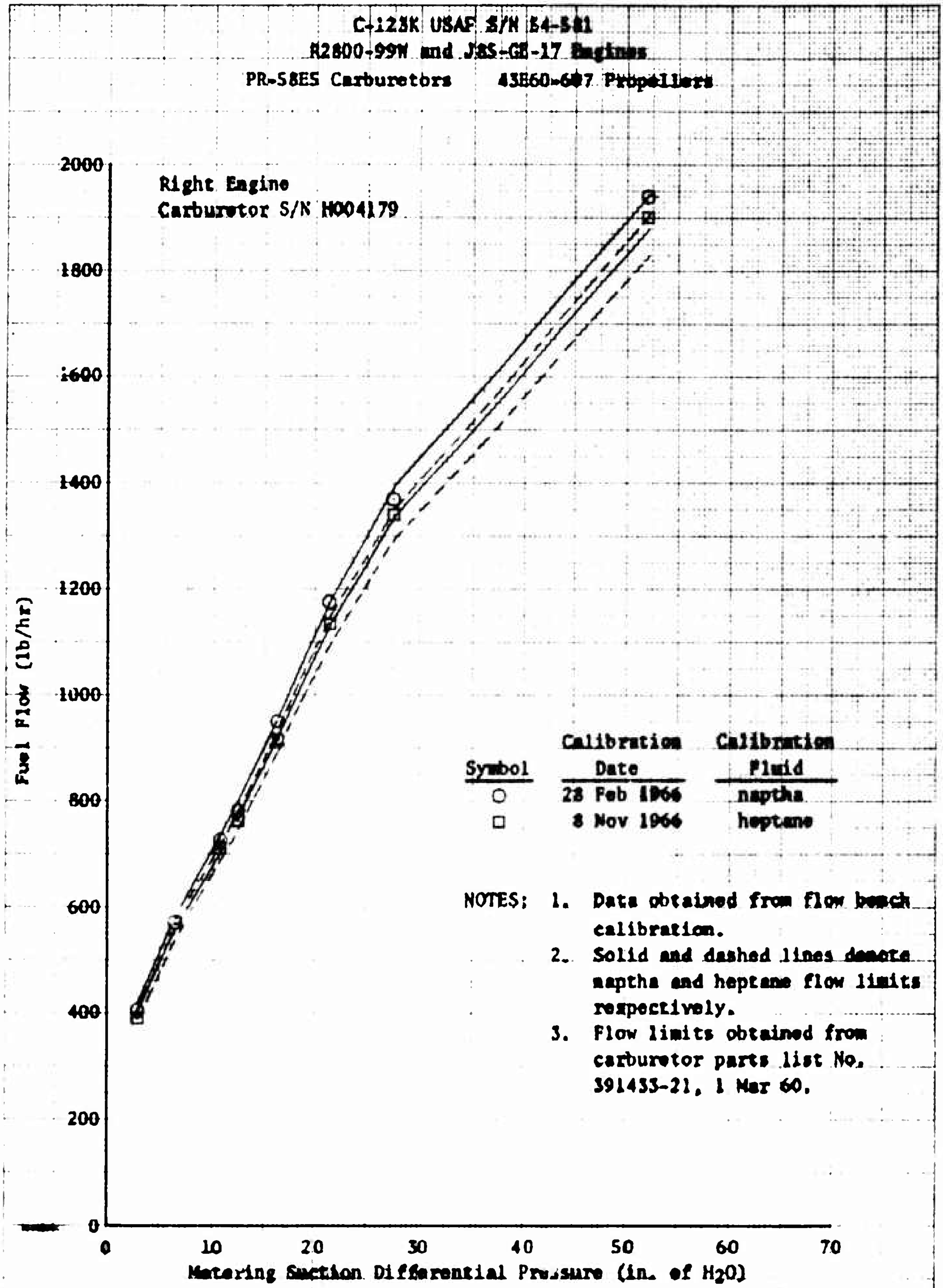


Figure 51. Carburetor Calibration

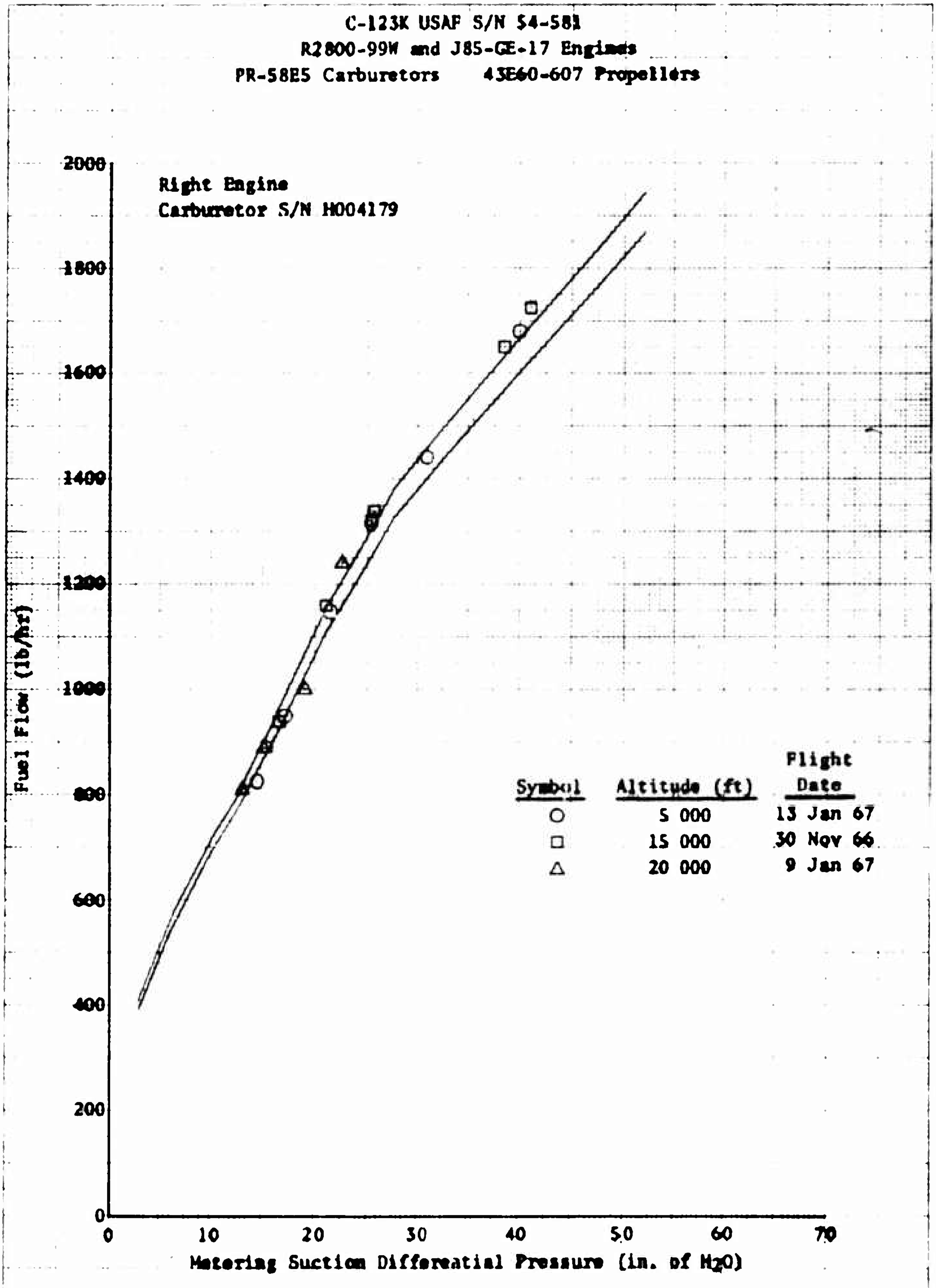


Figure 52. Carburetor Calibration

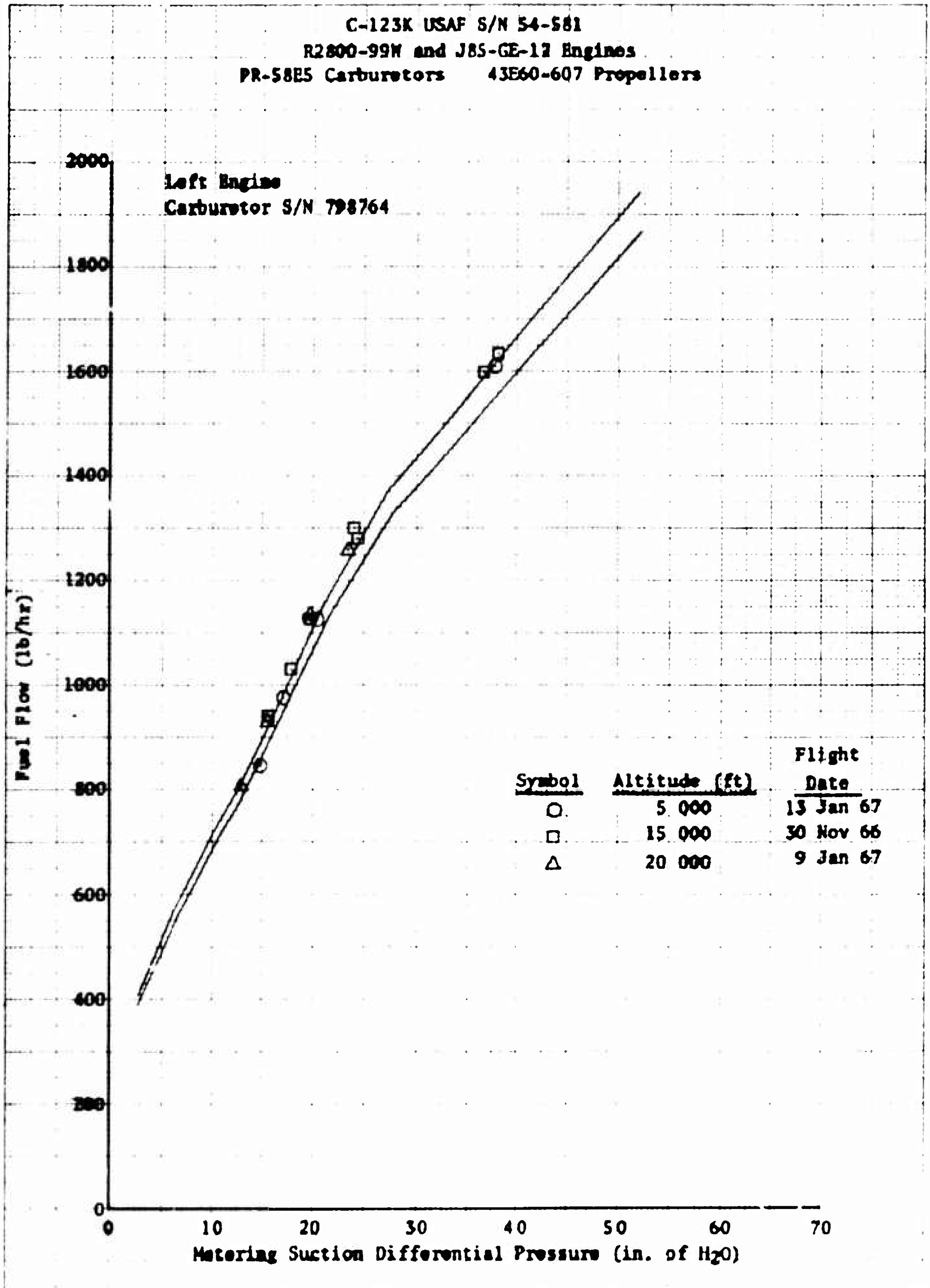


Figure 53. Carburetor Calibration

APPENDIX II

GENERAL AIRCRAFT INFORMATION AND FLIGHT LOG

GENERAL

DIMENSIONS AND DESIGN DATA

- **General**

Span	110 ft
Length	76.25 ft
Height	34 5 ft
Tread	12.5 ft

- **Wing**

Area (including ailerons, flaps, and fuselage)	1223.22 ft^2
Aspect ratio	9.89
Mean aerodynamic chord	140.248 in.

- **Ailerons**

Area (including trim tabs)	83.28 ft^2
Maximum deflection	20 deg up, 15 deg down

- **Flaps**

Area	128.0 ft^2
Maximum deflection	60 deg down

- **Vertical Tail**

Area (including dorsal fin and rudder)	255.03 ft^2
Rudder angular movement	20 deg each side

- **Horizontal Tail**

Area (including elevators)	345.54 ft^2
Elevator angular movement - up	25 deg
down	16.75 deg

OPERATIONAL LIMITATIONS

Design gross weight	54,000 lb
Maximum gross weight (landing gear ground handling limit)	60,000 lb
Center of gravity limit	
Forward	
Takeoff	20.6-pct MAC
In flight	18-pct MAC
Aft	32-pct MAC
Limit diving speed	245 KIAS
Maximum landing gear extension speed	135 KIAS
Maximum flap extension speed	132 KIAS
Maximum cargo door or ramp opening speed	130 KIAS

The airspeed limits stated above are equally applicable after the door or ramp has been opened, the wing flaps extended, or the landing gear extended.

POWER PLANT AND ACCESSORIES

Engines

reciprocating

Manufacturer	Pratt and Whitney
Model No.	R-2800-99W
Serial No.	
Left	P 31869
Right	P 31627
Supercharger	1 stage, 2 speed
Propeller reduction gear ratio	0.45:1
Torque constant	0.00632
Augmentation	water/alcohol
Fuel grade	115/145 AVGAS

jet

Manufacturer	General Electric
Model	J85-GE-17
Serial No.	
Left	GE-E-247003

Right GE-E-247001, GE-E-247019

Fuel grade 115/145 AVGAS

Carbureters

Manufacturer Bendix-Stromberg

Model PR-58E5

Parts list No. 391433-21

Serial No.

Left 798764

Right H 004179

Propellers

Manufacturer Hamilton Standard

Model No. 43E60-607

Blade drawing No. 6917B-14

Number of blades 3

Diameter 15 ft

TABLE I
ENGINE OPERATING LIMITS
RECIPROCATING ENGINES (R 2800-99W)

POWER SETTING	BHP	rpm	MAP (in. hg)	TOP (psi)	CHT (deg C)	TIME LIMIT
TAKEOFF						
WET	2,500	2,800	61.0	141.0	260	5 min
DRY	2,300	2,800	63.0	130.0	260	5 min
METO	1,900	2,600	51.5	115.5	260	NONE

JET ENGINES (J85-GE-17)

POWER SETTING	rpm (pct)	EGT (deg C)	TIME LIMIT
MILITARY RATED THRUST	100	692	30 min
NORMAL RATED THRUST	97.9	676	NONE

TEST INSTRUMENTATION

The flight test instrumentation was furnished jointly by the contractor and the AFFTC. All instrumentation was installed and maintained by the Fairchild-Hiller Corporation.

A photorecorder equipped with a 35mm motion picture camera was installed in the cargo compartment forward of the right wheel well (figure 1). The following calibrated instruments were installed in the photorecorder:

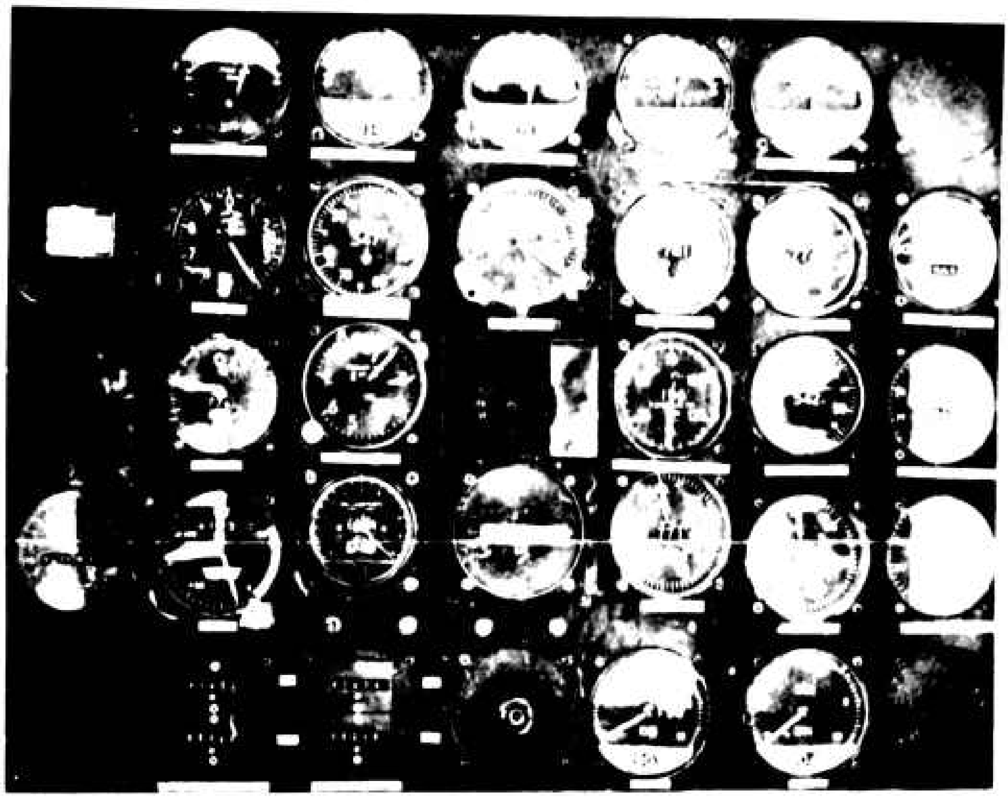


Figure 1 PHOTOPANEL

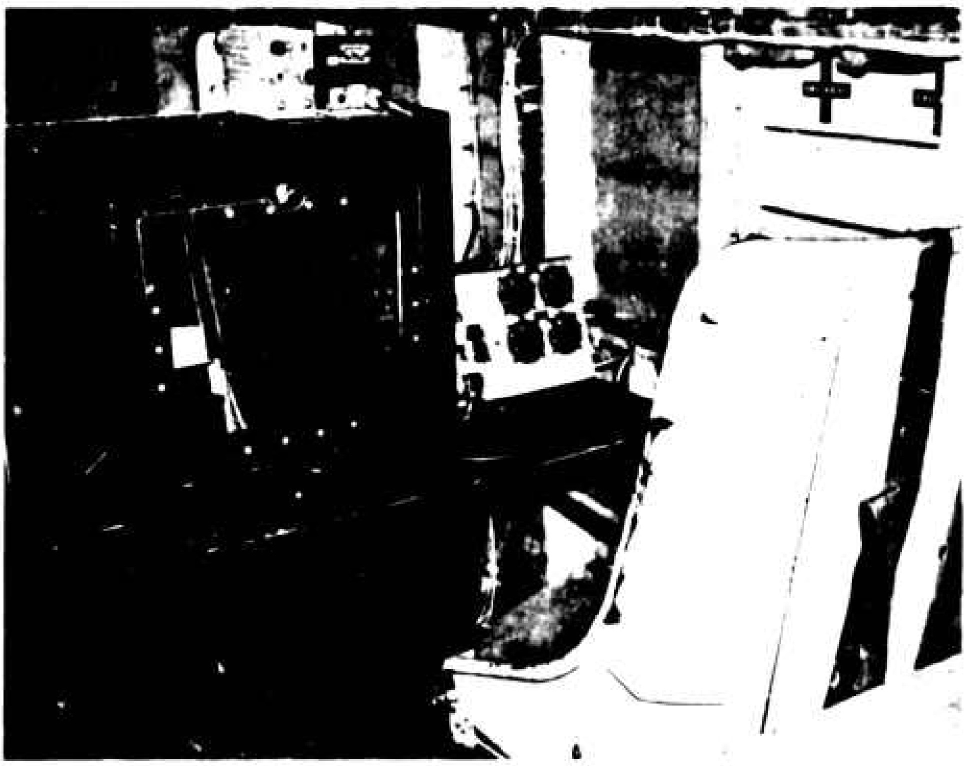


Figure 2 ENGINEER'S STATION

	Instrument Calibration Range
Airspeed (pilot's system)	50-250 kt
Altimeter	0-30,000 ft
Normal accelerometer	-1.5 to +4.0 g
Stall margin indicator	
OAT (Rosemount)	-40 to +100 deg C
Rudder force	0 $\pm$200 lb
Recip engine tachometer (2 engines)	600-3,000 rpm
Torque pressure (2 engines)	0-140 psi
Manifold pressure (2 engines)	10-70 in. Hg
Metering suction differential pressure (2 engines)	0-100 in. H_2O
Carburetor air temperature (2 engines)	$\pm$60 deg C
Jet engine tachometer (2 engines)	0-100 pct rpm
Exhaust gas temperature (2 jet engines)	50-950 deg C
Exhaust gas pressure (P_{t_5}) (2 jet engines)	30-75 in. Hg
Fuel temperature (4 engines)	$\pm$60 deg C
Fuel used counter (4 engines)	
Correlation counter	
Event light	
Clock (12 hour with sweep second hand)	

Mounted to the right of the photorecorder and operated by the flight test engineer were:

Stepper motor timers and stop watches to determine fuel flow rate (2 recip and 2 jet engines).

The following calibrated instruments were installed on the pilot's and copilot's instrument panels:

	Instrument Calibration Range
Airspeed (pilot's)	50-200 kt
Airspeed (copilot's)	50-200 kt
Altimeter (pilot's)	0-30,000 ft
Normal accelerometer	-1.5 to +4.0 g
Recip engine tachometer (2 engines)	600-3,000 rpm
Manifold pressure (2 engines)	10-70 in. Hg
Carburetor air temperature (2 engines)	-25 to +40 deg C

FLIGHT LOG

Flight	Flight Time	Date	Tests
K-2	0:59	1 Jun 66	C-123B speed power, 5,000 ft, 50,000 lb Cat I test
K-4	1:06	1 Jun 66	C-123B speed power, 20,000 ft, 40,000 lb Cat I test
K-22	2:00	3 Oct 66	Airspeed calibration
K-29	1:30	21 Oct 66	Speed power at 5,000 ft, 45,000 lb, power approach configuration
K-30	2:30	22 Oct 66	Speed powers at 5,000 ft, 60,000 lb and 50,000 lb, clean configuration
K-32		25 Oct 66	Static thrust calibration
K-33	2:15	27 Oct 66	Sawtooth climb at 15,000 ft, 60,000 lb; speed power at 15,000 ft, 55,000 lb, clean configuration
K-34	1:40	28 Oct 66	Sawtooth climb at 5,000 ft, 60,000 lb; speed power at 15,000 ft, 55,000 lb, clean configuration
K-35	0:50	28 Oct 66	Sawtooth climb at 5,000 ft, 45,000 lb, clean configuration
K-36	0:35	28 Oct 66	Sawtooth climb at 5,000 ft, 45,000 lb, clean configuration
K-37	2:15	29 Oct 66	Sawtooth climb at 15,000 ft, 45,000 lb; speed power at 20,000 ft, 45,000 lb, clean configuration
K-38	2:30	1 Nov 66	Stall speed determination
K-39	2:00	1 Nov 66	Stall speed determination
K-40	1:30	5 Nov 66	Air minimum directional control speed tests
K-41	0:15	12 Nov 66	FCF (carburetors recalibrated)
K-42	2:00	14 Nov 66	Airspeed calibration
K-43	0:40	14 Nov 66	Ferry to Fairchild-Hiller from Olmsted AFB
K-44	0:30	15 Nov 66	Ferry to Olmsted AFB
K-45		15 Nov 66	Ground minimum directional control speed tests
K-46	0:35	15 Nov 66	Ferry to Fairchild-Hiller
K-47	1:00	26 Nov 66	FCF (right jet engine changed); airspeed calibration, ground speed course
K-48	1:00	26 Nov 66	Speed power at 5,000 ft, 50,000 lb, jets asymmetric
K-49	1:20	27 Nov 66	Airspeed calibration, ground speed course
K-50	1:35	30 Nov 66	Speed power at 15,000 ft, 55,000 lb, jets at 90-percent rpm

Flight	Flight Time	Date	Tests
K-51	1:10	30 Nov 66	Speed power at 15,000 ft, 45,000 lb
K-52	1:35	1 Dec 66	Speed power at 15,000 ft, 45,000 lb
K-53	1:00	2 Dec 66	C-123B airspeed calibration - pace
K-54	1:45	3 Dec 66	Three-engine check climb, 56,000 lb
K-55	1:45	5 Dec 66	Takeoff and landing tests, 60,000 lb
K-56	2:55	9 Dec 66	Takeoff and landing tests, 60,000 and 45,000 lb
K-57	2:05	15 Dec 66	Three-engine check climb and stall speed determination, 56,000 lb
K-58	1:25	17 Dec 66	Monitair evaluation
K-59	1:40	18 Dec 66	Monitair evaluation
K-60	0:10	5 Jan 67	Aborted four-engine climb, 48,000 lb (heater explosion)
K-61	1:20	5 Jan 67	Four-engine climb, 48,000 lb stall investigation
K-62	2:10	9 Jan 67	Stalls in clean and takeoff configurations; descents; decelerations in climb configurations; speed powers at 20,000 ft, 45,000 lb; fuel flow data at 15,000 ft
K-63	1:50	9 Jan 67	Air minimum directional control speed tests; takeoff and landing tests, 45,000 lb
K-64	1:10	10 Jan 67	Landings, 60,000 lb
K-65	0:50	10 Jan 67	Monitair evaluation
K-66	1:20	12 Jan 67	Monitair evaluation
K-67	0:35	13 Jan 67	Fuel flow data
K-68	0:25	17 Jan 67	FCF (carburetor changed)
K-69	1:25	21 Jan 67	Four-engine continuous climb, 60,000 lb
K-70	1:25	21 Jan 67	Four-engine continuous climb, 60,000 lb
K-71	1:20	21 Jan 67	Three-engine continuous climb, 56,000 lb
K-72	1:30	23 Jan 67	Four-engine continuous climb, 48,000 lb; air minimum directional control speed test - stalls

Total flight test time not including flights K-2 or K-4 = 59 hours 20 minutes.

APPENDIX IV

EVALUATION OF THE MONITAIR ANGLE OF ATTACK/STALL WARNING SYSTEM[4]

INTRODUCTION

The Monitair angle of attack/stall warning system was installed in C-123K aircraft to provide both visual and physical stall warning at a predetermined margin above stall speed. The system also provided a continuous visual presentation of stall margin.

The system was installed and calibrated in the C-123K test aircraft, USAF S/N 54-581, at the Fairchild-Hiller Corporation, Hagerstown, Maryland, by Monitair Corporation personnel. System tests were conducted by AFFTC personnel in conjunction with the C-123K limited performance tests during the period 21 October 1966 through 23 January 1967.

SYSTEM DESCRIPTION

The system consisted of a sensor vane on a wing mounted pylon, a circuit box, a flap position compensator, and a cockpit indicator. Panel mounted controls were provided in the cockpit to control indicator lighting intensity, and to provide test capability for the Monitair system and the original control column shaker.

[4] A Summary Report on the Montair System was sent to Prime Air Materiel Depot, Warner Robins Air Materiel Area, on 31 March 1967. The final report is presented here as appendix IV.

The electrical circuit of the system was basically a dual bridge circuit which provided independent signals for the stall margin indicator and the stall warning functions. Electrical power was supplied from the aircraft's 28-volt primary dc bus.

The pylon mounted transmitter was installed on the leading edge of the right wing. Angle of attack changes were sensed by a vane which positioned dual potentiometers in the transmitter. Deicing protection, provided by an electrical heater in the vane and pylon, was connected to the aircraft pitot heat circuit.

The circuit box was located in the left side equipment rack in the cargo compartment. The four circuits contained in the box provided a means of calibration for the stall margin indicator and stall warning circuits as well as test circuits for these functions.

The flap position compensator was installed on the rear edge of the wing center section in the cargo compartment and was connected to the wing flap torque tube. This compensator contained dual potentiometers to provide continuous compensation at all flap positions for both the stall margin indications and stall warning.

The stall margin indicator (figure 1, appendix IV) was mounted on top of the pilot's glare shield at an angle to reduce parallax errors in the low speed range. The indicator provided a visual indication of speed based on coefficients of stall speed. The coefficients were intended to be equal to the ratio of existing speed to the stall speed for that configuration. A moveable pointer indicated low speed on a linear scale ranging from 0.9 to 1.4 V_s. A linear scale numbered from 1 to 6 was also provided in the high speed range. The indicator was back lighted through a multicolored scale.

During the test program, switches were mounted in the throttle quadrant to provide a signal to compensate for power effects on stall speed. These switches provided bias to the stall margin indication and stall warning circuits when either throttle was retarded to less than the approximate zero thrust position. This compensation was required due to the loss of lift caused by windmilling propellers disturbing the airflow over the wing.

The Monitair system was calibrated following the procedure outlined in T.O. 1C-123B-634 (reference 10) prior to the beginning of this evaluation. During the flight test program an additional indicator was installed in the photopanel of the test aircraft. Addition of this indicator changed the resistance across the bridge circuit for the stall margin indicator and required recalibration of the system.

TEST AND EVALUATION

COCKPIT INSTALLATION

The stall margin indicator was mounted on top of the glare shield to a bracket which protruded through the glare shield and was fastened to the pilot's instrument panel. This location caused the indicator to obstruct the pilot's forward vision slightly, but also allowed almost continuous monitoring during critical phases of visual flight. Stall margin indications were unreadable from the copilot's position. A second indicator should be installed in a similar location above the copilot's glare shield. (R 24)[5]

[5] Numbers indicated as (R 24), etc., represent the corresponding recommendations number as tabulated in the Conclusions and Recommendations section of the main report.

Electrical power for the Monitair system was supplied from the aircraft's 28-volt primary dc bus. The primary and flight emergency busses are normally connected whenever any generator is operating. They are automatically separated if a complete generator failure occurs and only the flight emergency bus may be powered by the battery. Thus, in the event of a complete generator failure, stall warning provided by the Monitair system would not be available. This condition is unsatisfactory and the Monitair system should therefore be connected to the aircraft flight emergency bus. (R 25)

The indicator dial originally installed on the test aircraft (figure 1, appendix IV) proved to be unacceptable. The indices of the original dial (part number 3015) were referenced to limited data obtained from flight tests of a C-123B aircraft (reference 11). They were incorrect for a C-123K aircraft and were so numerous as to make the scale unreadable. The original dial was replaced early in the evaluation by a simplified presentation as shown in figure 1. This simplified presentation added a linear coefficient of stall speed scale from 0.9 to 1.4 V_s and a separate linear scale numbered from 1 to 6 over the remainder of the instrument range. A multicolored scale was incorporated to provide a gross indication of stall margin.

Although the aircraft was not flown at night, the instrument lighting was observed after dark and the lighting was judged to be uniform and satisfactory.

No electromagnetic interference between the Monitair system and other aircraft electrical systems was noted.

TAKEOFF AND INITIAL CLIMB

The angle of attack of an aircraft wing remains constant during the takeoff ground roll prior to rotation. For this reason the stall margin indicator could not be used to indicate arrival at rotation airspeed. However, during rotation and lift-off the indicator needle rapidly moved to the proper indication and could be used as a reference for initial climbs.

During initial climb, the pilot's view of the horizon was blocked due to the high aircraft pitch attitude. In addition, the pilot's attitude indicator did not have pitch reference lines. The initial climb airspeed was difficult to maintain due to lack of a suitable reference for use in making small corrections to the aircraft pitch attitude. The proper stall margin indication was easier to maintain, and thus the stall margin indicator should be used as a reference during initial climb. Recommendations regarding the proper stall margin indication for use during initial climb are contained in the Takeoff section of the main report. (R 26)

CONTINUOUS CLIMBS

The Monitair system was not evaluated as a primary flight instrument during continuous climbs although its operation was observed during climb tests. The recommended climb speed for the C-123K (130 KIAS) did not correspond to a constant angle of attack at all gross weights and therefore a constant stall margin indication could not be used for all climb conditions. However, the stall margin indicator can be used to advantage by the pilot to help maintain a constant indicated airspeed in the climb by stabilizing on the desired speed, noting the indicator reading, and then using trend information from the indicator in conjunction with the airspeed indicator for proper speed control.

LEVEL FLIGHT

The Flight Manual cruise charts indicated that best cruise did not occur at a constant lift coefficient, and therefore a constant stall margin indication could not be used for cruise. However, the instrument can be used as noted under continuous climbs or by tabulating indications for various gross weights and altitudes for use by the pilot.

STALLS AND STALL WARNING

Tests were conducted to determine the accuracy of the stall margin indication and the compliance of the artificial stall warning with MIL-F-8785(ASG) requirements. These tests consisted of slowing the aircraft from the highest practical airspeed to stall speed at various combinations of gross weight, engine power setting, wing flap position, and landing gear position. These test data were corrected to the corresponding airspeed for a 50,000-pound airplane by multiplying the indicated airspeed corrected for instrument error at each test point by:

$$\left[\frac{50,000}{W}\right]^{1/2}$$

These data are presented in figures 2 through 5 and summarized in tables I and II, appendix IV.

Errors in stall margin indication at stall resulted from either improper wing flap compensation or improper power compensation. Errors in wing flap compensation were determined by stalling the aircraft with power equivalent to zero thrust (2,400 rpm, 16 inches MAP) at various wing flap settings. Since the system was calibrated to indicate 1.0 V_s at stall with LAND flaps extended and power for zero thrust, any variation in stall margin indication from a value of 1.0 V_s was attributed to improper flap compensation.

TABLE I
ACCURACY OF MONITAIR SYSTEM AT STALL AND STALL WARNING
JET ENGINES INOPERATIVE

FLAP SETTING	POWER	MONITAIR INDICATION AT STALL	MONITAIR INDICATION AT WARNING[2]	ACTUAL SPEED AT 1.0 V_s INDICATION	ACTUAL SPEED AT WARNING
UP	ZERO THRUST[1]	1.00 V_s	1.10 V_s	1.00 V_s	1.12 V_s
UP	THROTTLES CLOSED	0.99 V_s	1.10 V_s	1.01 V_s	1.13 V_s
TAKEOFF (20 deg)	ZERO THRUST	0.98 V_s	1.10 V_s	1.02 V_s	1.12 V_s
TAKEOFF (20 deg)	THROTTLES CLOSED	0.99 V_s	1.10 V_s	1.01 V_s	1.11 V_s
LAND (45 deg)	ZERO THRUST	1.00 V_s	1.10 V_s	1.00 V_s	1.10 V_s
LAND (45 deg)	THROTTLES CLOSED	1.00 V_s	1.10 V_s	1.00 V_s	1.09 V_s
FULL (60 deg)	ZERO THRUST	1.01 V_s	1.10 V_s	0.99 V_s	1.09 V_s
FULL (60 deg)	THROTTLES CLOSED	1.00 V_s	1.10 V_s	1.00 V_s	1.09 V_s

NOTES: 1. Zero thrust was approximated by a power setting of 2,400 rpm and 16 inches Hg MAP.
2. Warning – Control column shaker actuation.

TABLE II
ACCURACY OF MONITAIR SYSTEM IN THE APPROACH RANGE
JET ENGINES INOPERATIVE

FLAP SETTING	POWER	MONITAIR INDICATION AT 1.2 V_s	ACTUAL SPEED AT 1.2 V_s INDICATION	MONITAIR INDICATION AT 1.3 V_s	ACTUAL SPEED AT 1.3 V_s INDICATION
UP	ZERO THRUST[1]	1.17 V_s	1.24 V_s	1.25 V_s	1.36 V_s
UP	THROTTLES CLOSED	1.17 V_s	1.24 V_s	1.25 V_s	1.36 V_s
TAKEOFF (20 deg)	ZERO THRUST	1.18 V_s	1.22 V_s	1.27 V_s	1.33 V_s
TAKEOFF (20 deg)	THROTTLES CLOSED	1.20 V_s	1.20 V_s	1.30 V_s	1.30 V_s
LAND (45 deg)	ZERO THRUST	1.20 V_s	1.20 V_s	1.30 V_s	1.30 V_s
LAND (45 deg)	THROTTLES CLOSED	1.23 V_s	1.18 V_s	1.33 V_s	1.27 V_s
FULL (60 deg)	ZERO THRUST	1.21 V_s	1.19 V_s	1.32 V_s	1.28 V_s
FULL (60 deg)	THROTTLES CLOSED	1.23 V_s	1.17 V_s	1.34 V_s	1.26 V_s

NOTE: 1. Zero thrust was approximated by a power setting of 2,400 rpm and 16 inches Hg MAP.

The throttles were then closed (idle power), and the stall margin indication at stall was noted. Any variation in stall margin indication from that determined with power for zero thrust was attributed to improper power compensation.

The stall margin indication was correct only if stall actually occurred at 1.0 V_s on the indicator and the slope of the stall margin indication versus airspeed line was correct for each configuration and power setting. As mentioned previously, stall did not always occur at an indicated value of 1.0 V_s, and thus the stall margin indication was not exact for those particular configurations. It can also be noted from examination of figures 2 through 5, appendix IV, that the stall margin indication versus airspeed fairing differs from the desired line in some cases. These inaccuracies combine to give the errors shown in tables I and II, appendix IV.

The error in stall margin indication in the cruise configuration with power for zero thrust was caused by an improper slope of the stall margin indication versus airspeed line. With throttles closed the error in stall margin was a result of both improper slope and improper power compensation.

Improper flap compensation caused errors in indicated stall margin and indication at stall with TAKEOFF flaps extended.

With the flaps in the LAND position and power equivalent to zero thrust, errors in stall margin indication were negligible. With the throttles closed, a small error was introduced due to improper slope of the stall margin indication versus airspeed line.

With the flaps fully extended, errors were introduced due to improper flap compensation in both the zero thrust and throttles closed conditions. With throttles closed, errors were also introduced due to improper slope of the stall margin indication versus airspeed line.

Stall summary plots for idle power and power for zero thrust are presented in figures 12 and 13, appendix IV, respectively. Stall speeds and stall margin indication were unaffected by landing gear position. It should be noted that in the clean configuration with the throttles closed, a 3-percent error existed in stall margin indication at control column shaker actuation. This error in stall margin indication in the clean configuration was conservative (indicating less margin that was actually available). In all other conditions with either zero thrust or idle power, errors in stall margin indication at warning and stall were less than 2 percent.

Stall warning provided by the Monitair system met MIL-F-8785(ASG) requirements at all flap settings with either power for zero thrust or with throttles closed.

POWER EFFECTS

Switches within the throttle quadrant were provided to compensate for increased stall speeds when either throttle was retarded to a power less than approximately that for zero thrust. Closing the throttle actuated the switch causing the stall warning indicator needle to be depressed 0.06 on the scale. The idle power stall speed was approximately 5 knots higher than the zero thrust stall speed in the cruise configuration, and approximately 7 knots higher with the flaps fully extended. The magnitude of the compensation was selected to give a correct stall margin indication at stall with LAND flaps extended. Since a constant compensation was provided by the throttle switches, a small error was introduced when the flaps were not in the LAND position. This error in stall margin indication at stall was less than 2 percent. This small error was satisfactory.

Stall tests were conducted for power settings ranging from power for zero thrust to 1,100 BHP to determine the effect of positive thrust on stall warning and stall margin indication at stall. Figure 7, appendix IV shows that increasing thrust had the effect of increasing the vane angle at stall due to an increase of the angle of attack at stall. A stall margin indication of 1.0 V_S occurred at only one vane angle for each configuration. Since no compensation was provided for power above zero thrust, stall occurred at progressively decreasing stall margin indications as power was increased. At 1,100 BHP, artificial stall warning occurred at 1.1 V_S on the indicator and stall occurred at an indicated value of 0.95 V_S. The actual speed at shaker actuation was 1.16 V_S.

Tests were also conducted at high power settings (up to 2,440 BHP) at which poor stall characteristics made it undesirable to stall the aircraft. Under these high power conditions, stall margin indication was recorded as the aircraft was slowed from highest practical airspeed to control column shaker actuation airspeed. Results of these tests are shown in figures 6 through 9, appendix IV. These data show that high reciprocating engine power settings cause "peel offs" on the stall margin indication versus airspeed plot. These peel offs occur at progressively higher stall margin indications with increasing power and are the result of decreased angle of attack due to the increased propeller thrust.

In the takeoff flap configuration with wet takeoff power on the reciprocating engines and maximum power on the turbojet engines, stall warning (control column shaker actuation) occurred at 79 KIAS and an indicated value of 1.1 V_S. If it is assumed that stall would have occurred at the Flight Manual stall speed (as indicated on the takeoff charts) of 68 KIAS for this condition, the actual speed was 1.16 V_s at shaker actuation. This error in stall margin indication was conservative.

ACCELERATED FLIGHT

One deceleration to an accelerated stall was accomplished to determine the effect of normal acceleration on stall margin indication. The results of this test are shown in figure 10, appendix IV.

SIDESLIP

Decelerations during constant heading sideslips were accomplished to determine the effect of sideslip on stall margin indication. Airspeed could not be directly used as a reference in determining sideslip effect on the indication since the production C-123K pitot-static system produced erroneous airspeed indications in a sideslip. Comparing the stall margin indication during the sideslip with that in level flight at an airspeed equal to the average of the pilot's and copilot's indicated airspeeds during the sideslip revealed no differences between stall margin indication in a sideslip or in straight flight at the same speed.

LANDING

All types of visual landing approaches were flown using the stall margin indicator as the primary flight instrument for speed control. An indication of 1.3 V_s was used for normal approaches in all configurations except flaps up. Flaps up approaches were flown at an indicated value of 1.25 V_s. This indication corresponded to an actual speed of 1.3 V_s due to a 5-percent error in stall margin indication in the cruise configuration. Maximum performance approaches with full flap deflection were flown at an indication of 1.2 V_s. Recommendations regarding indications for various types of approaches are contained in the Landing section of the main report.

The stall margin indicating system was optimized for use as a speed control instrument during landing approaches. When examining the system errors shown in table II, appendix IV, it should be remembered that normal approach power for the C-123K was equal to or greater than power for zero thrust. System errors at power for zero thrust were very small and the indicator thus made an excellent primary instrument for speed control during landing approaches. The stall margin indicator's position on the glare shield allowed the pilot to watch the runway for a larger percentage of time than when using the airspeed indicator as a primary instrument for speed control. Speed control was easier and more precise than was possible by reference to the airspeed indicator alone. The stall margin indicator should be used as the primary instrument for speed control during visual approaches. (R 27)

The Flight Manual warned against making approaches with the throttles closed. When the throttles were closed during an approach, the system provided adequate stall warning.

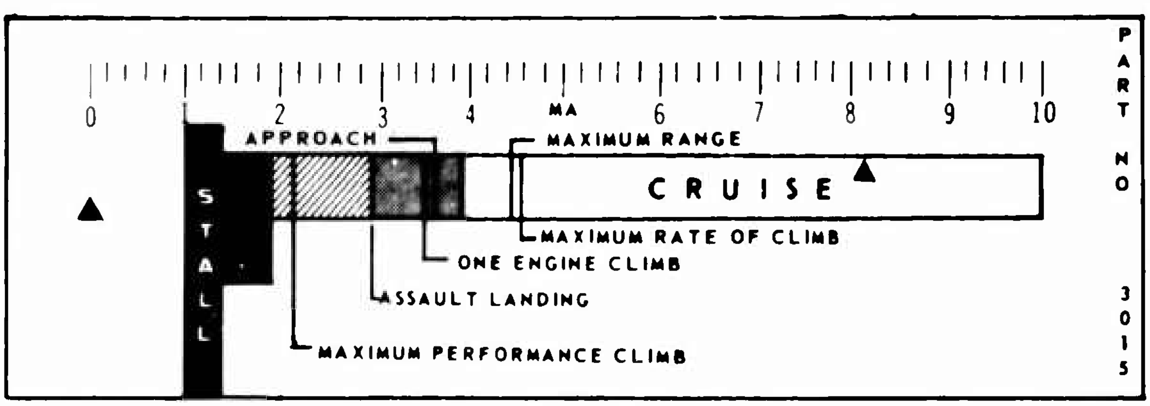
The damping of the stall margin indicator pointer was such that turbulence caused pointer fluctions slightly greater in magnitude than those of the production C-123K airspeed indicator. The fluctuations encountered were acceptable.

■ RELIABILITY

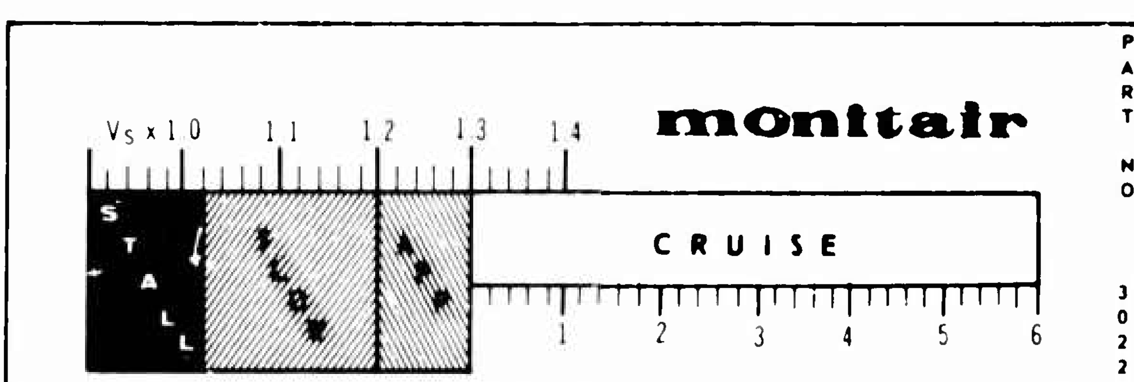
No system malfunctions were noted during this evaluation; however, the limited amount of flying time expended in evaluation of the Monitair system was not adequate to judge its reliability.

■ ADVERSE WEATHER OPERATION

The anti-icing capability of the Monitair system was evaluated during Category I flight tests conducted at Wright-Patterson AFB, Ohio. The results of these tests will be reported by the Monitair Corporation.



ORIGINAL CONFIGURATION



FINAL CONFIGURATION

Figure . STALL MARGIN INDICATOR PRESENTATION

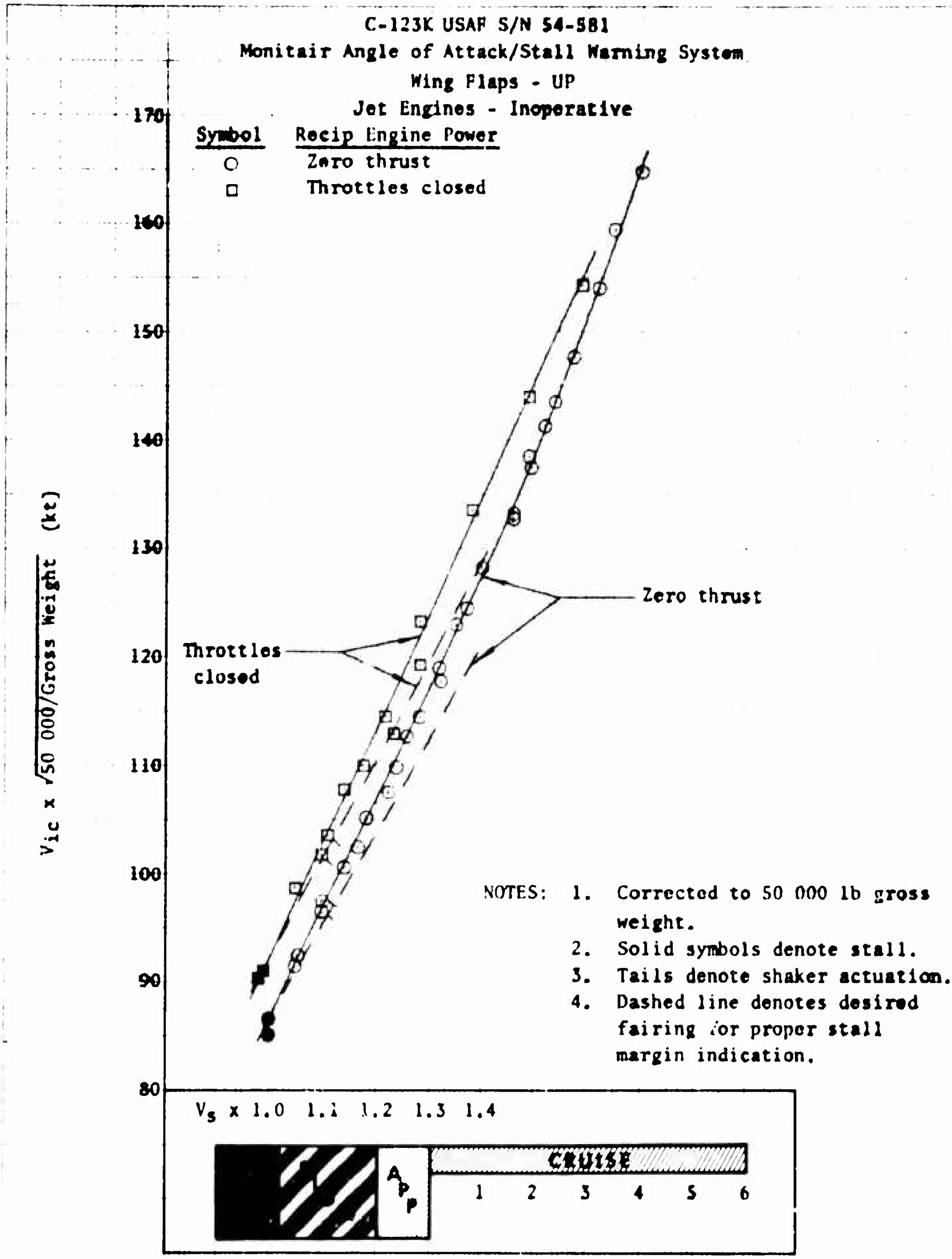


Figure 2 . Stall Margin Indication vs Indicated Airspeed

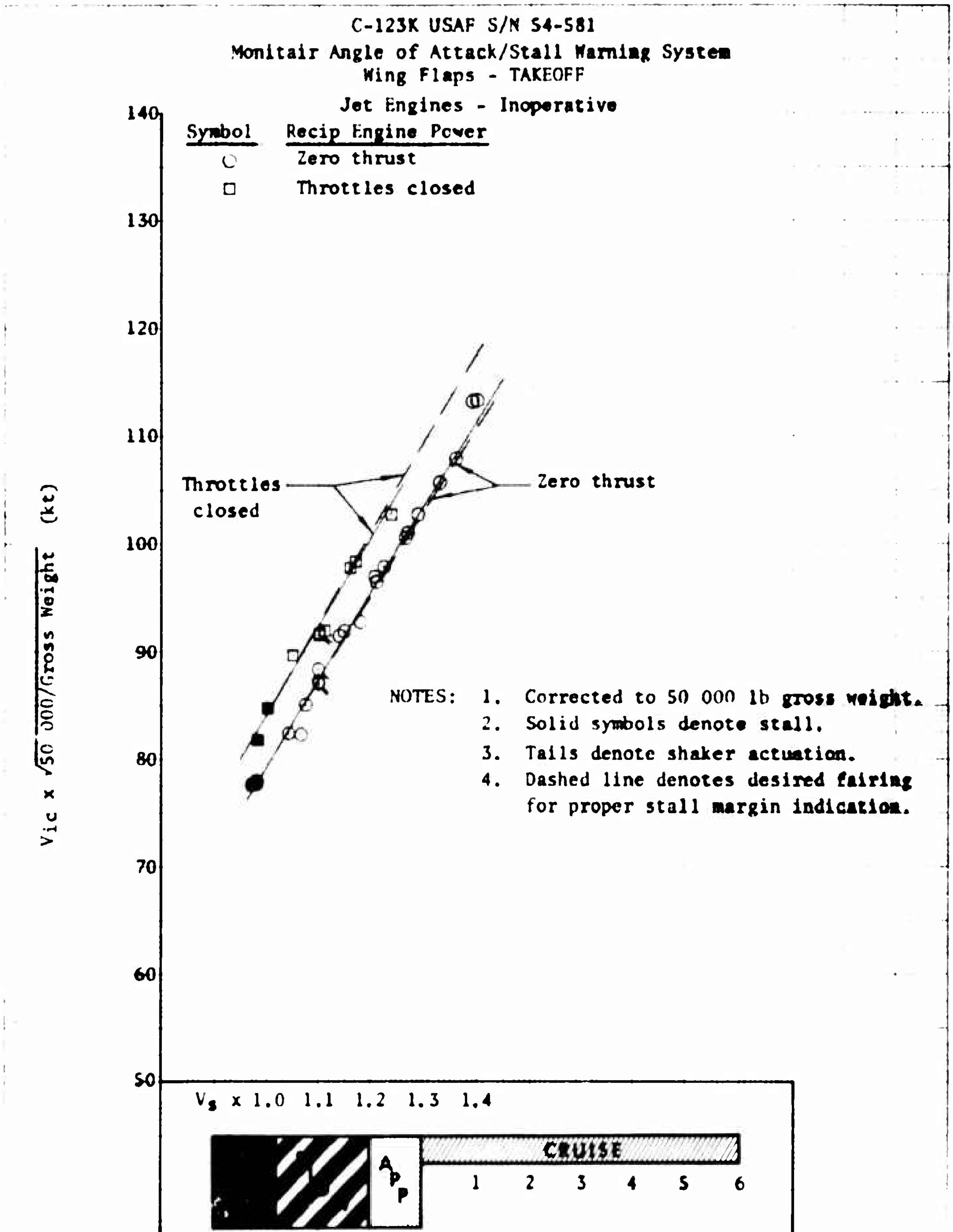


Figure 3. Stall Margin Indication vs Indicated Airspeed

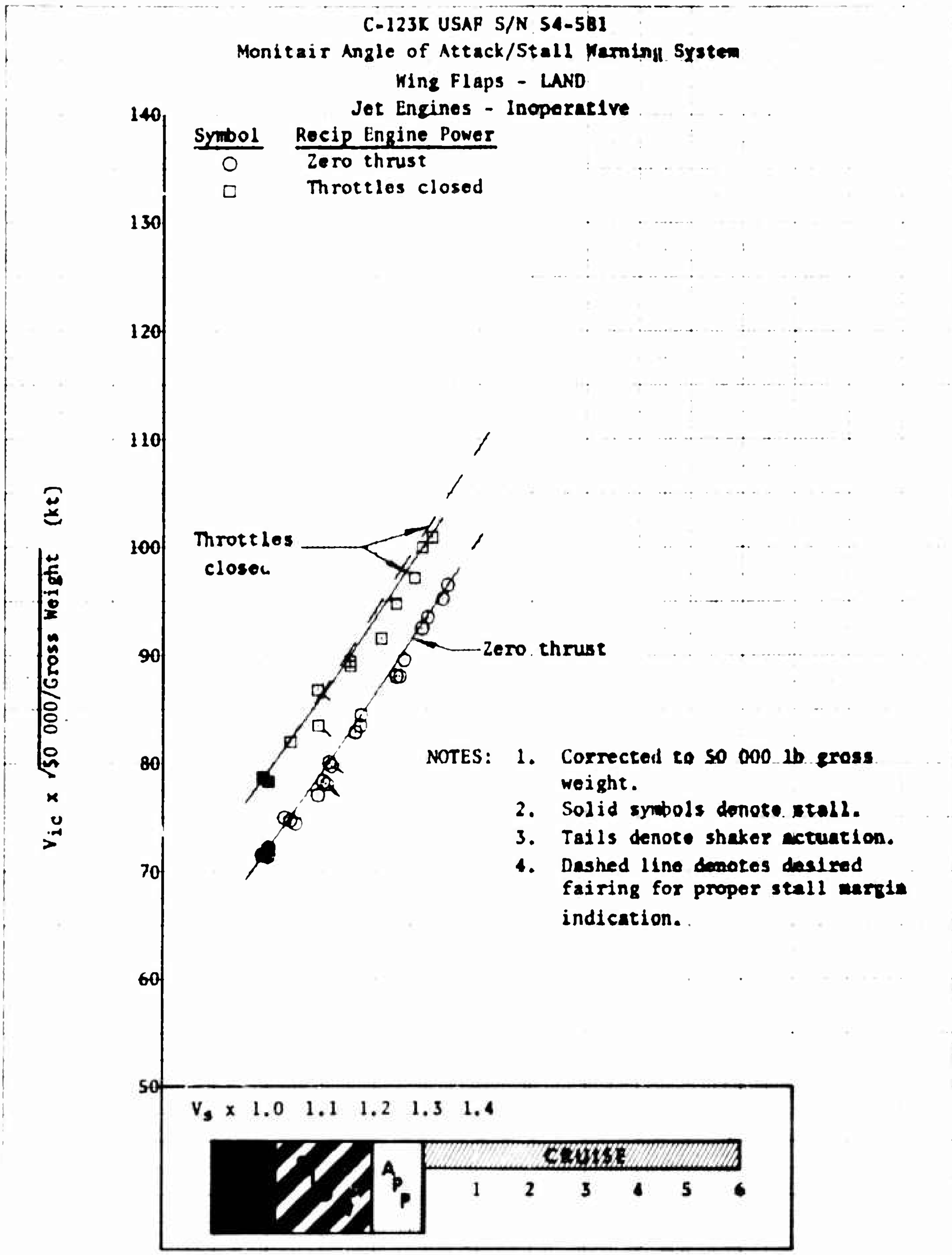


Figure 4. Stall Margin Indication vs Indicated Airspeed

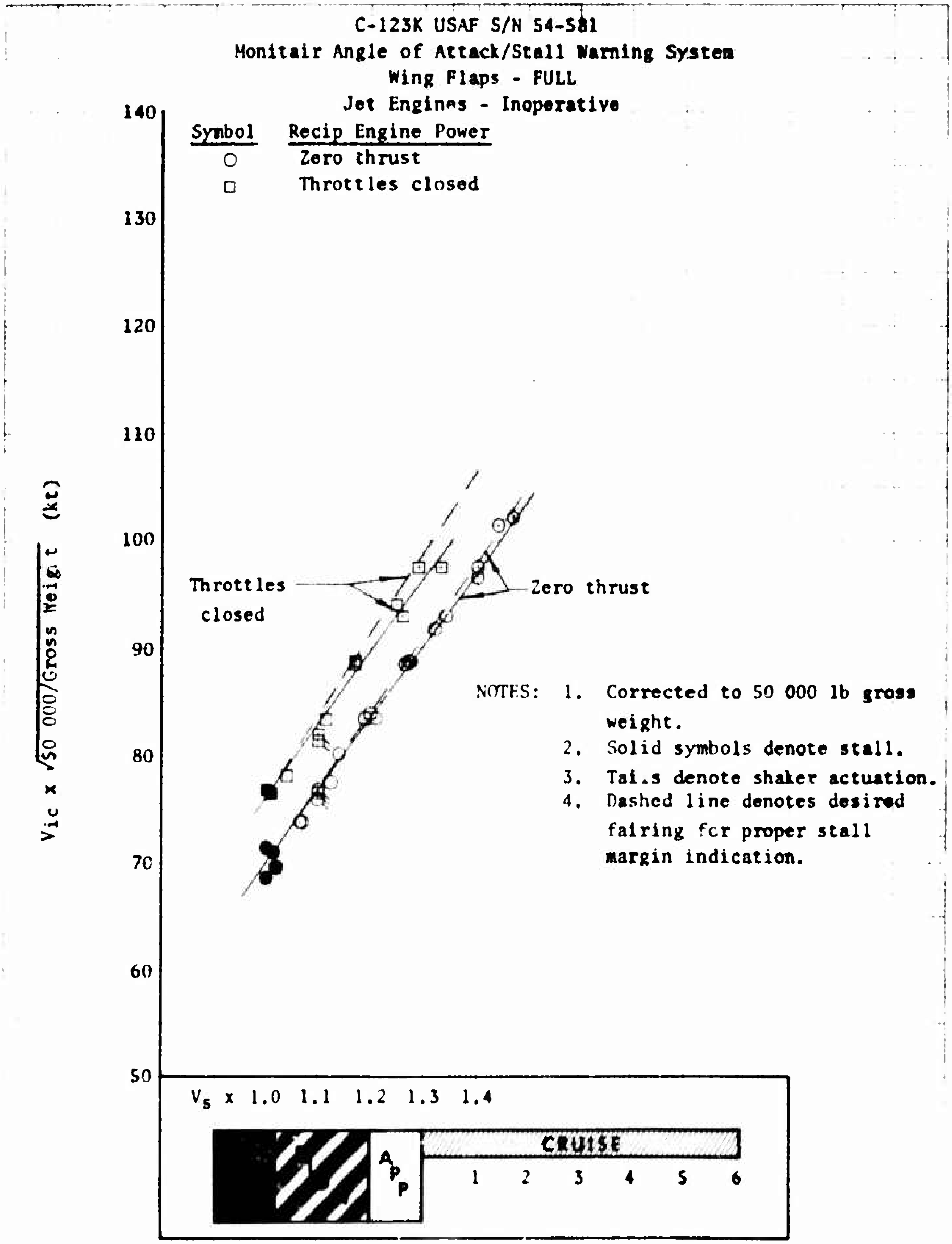


Figure 5. Stall Margin Indication vs Indicated Airspeed

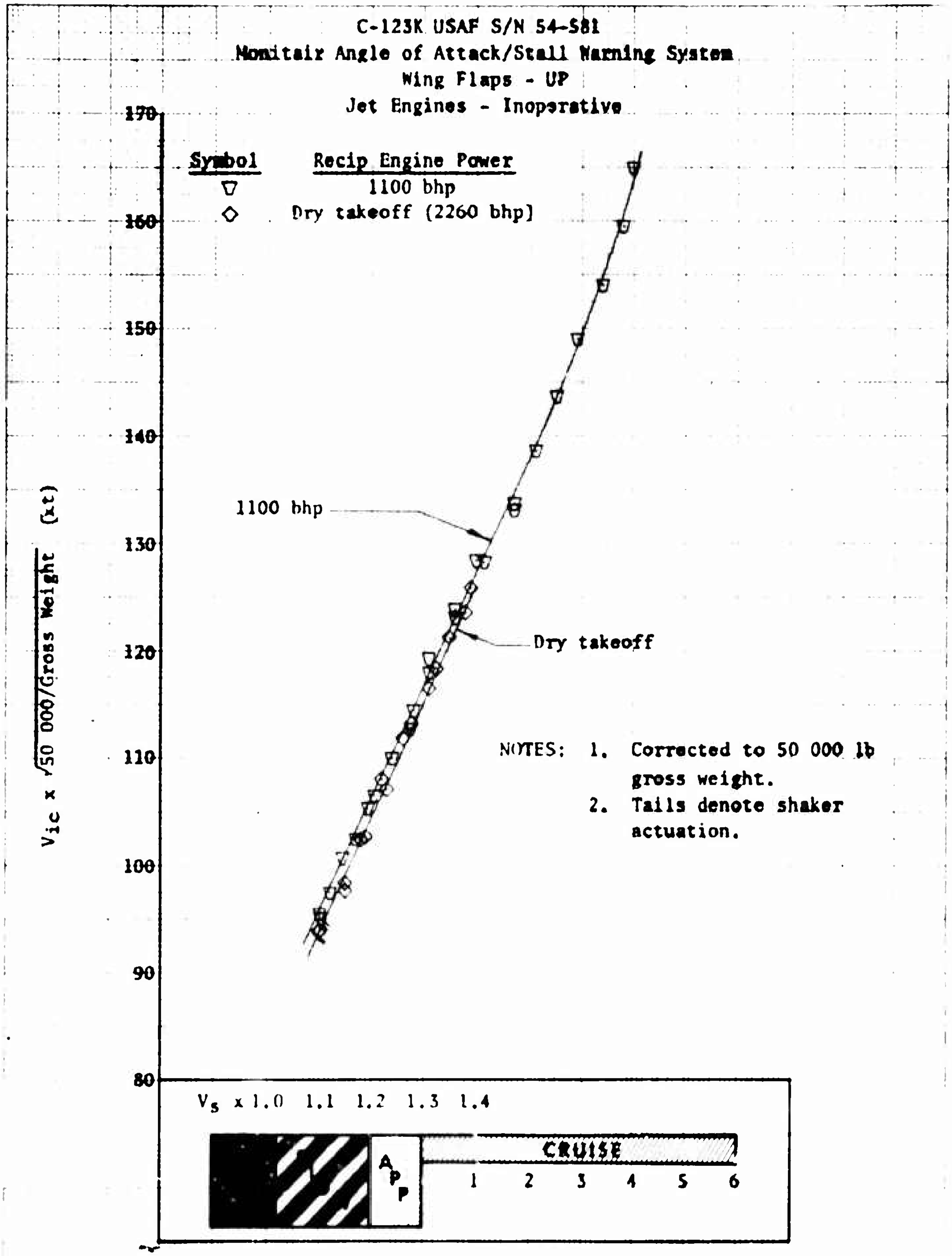


Figure 6. Stall Margin Indication vs Indicated Airspeed

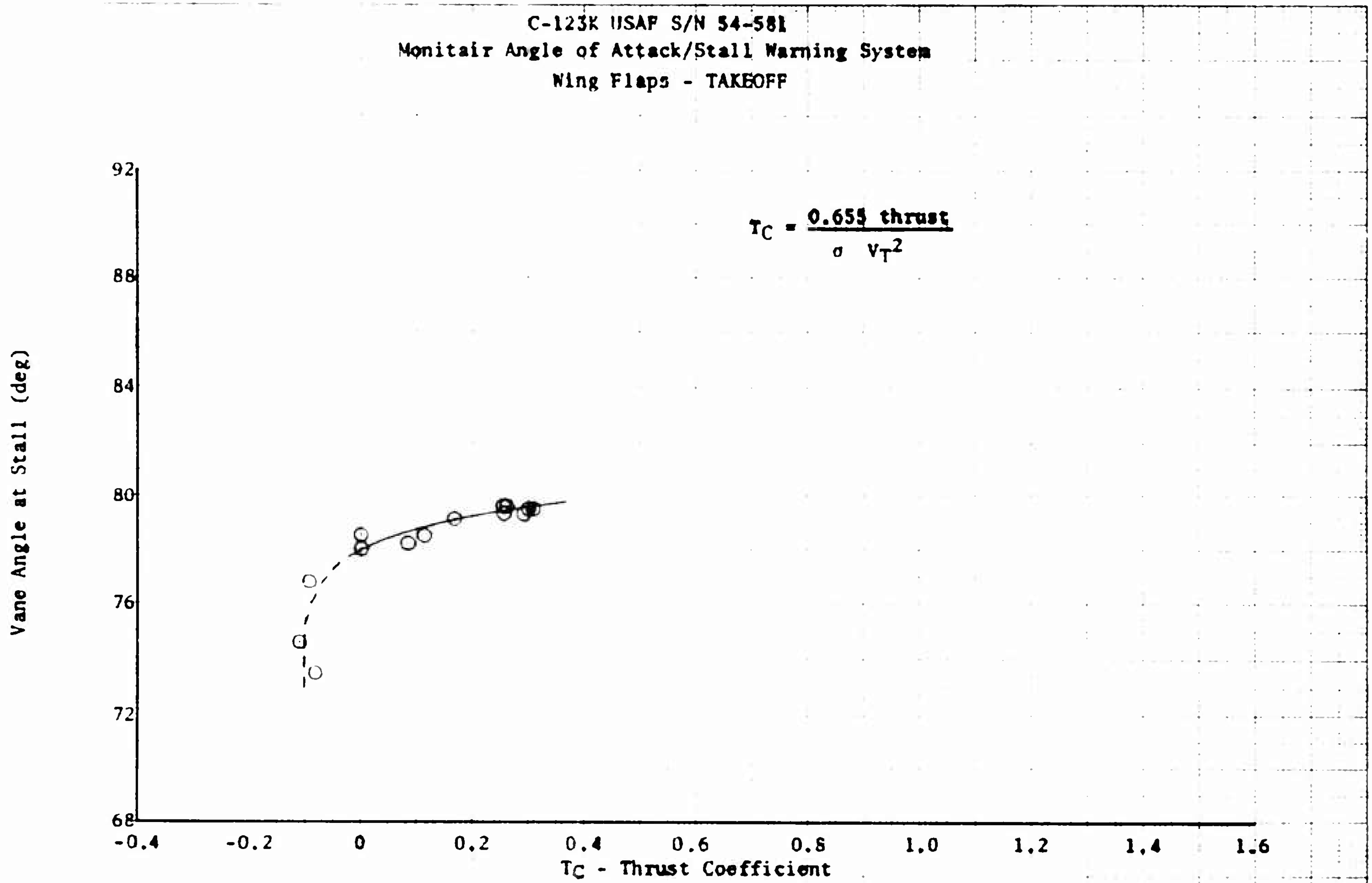


Figure 7. Vane Angle at Stall vs Thrust Coefficient

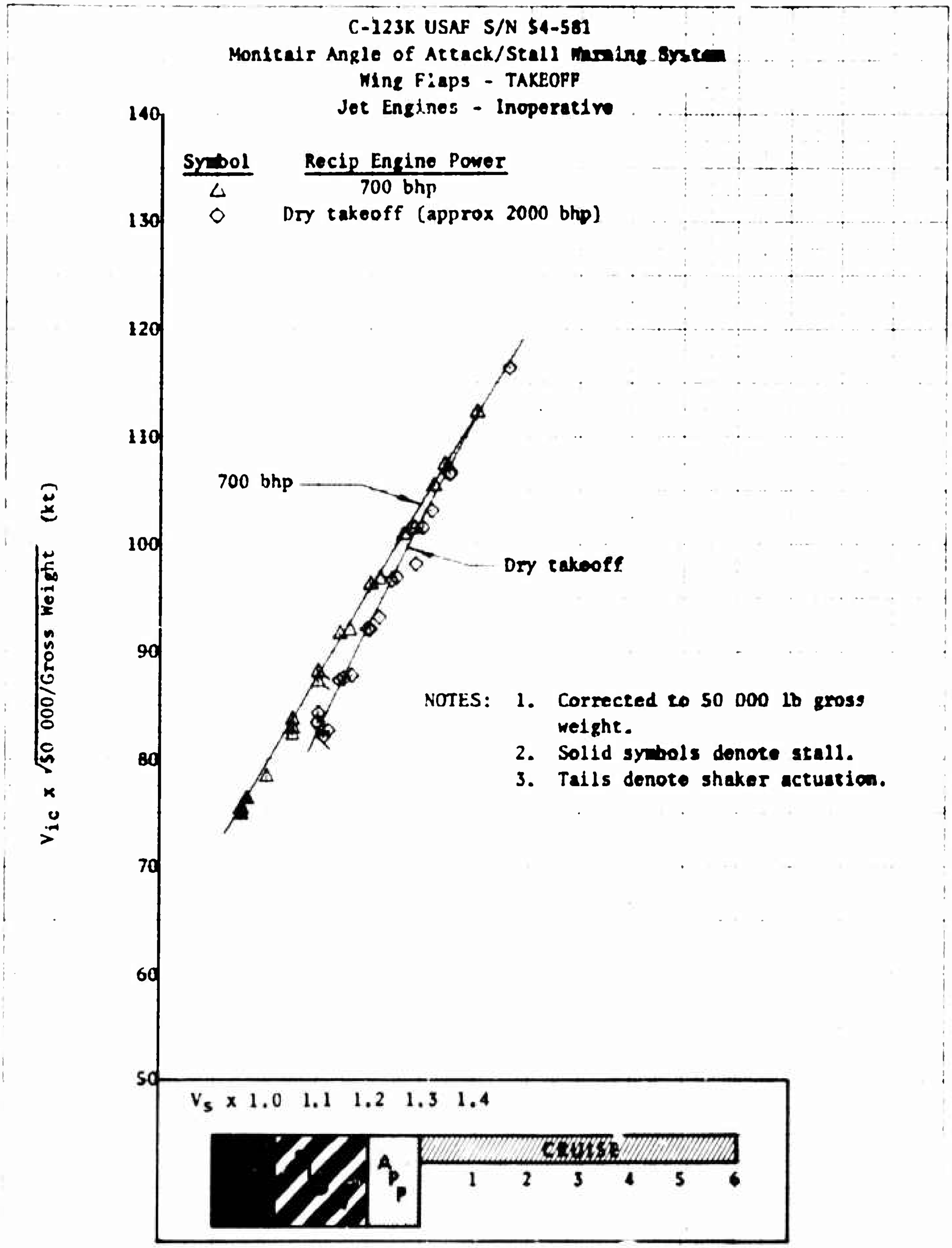


Figure 8. Stall Margin Indication vs Indicated Airspeed

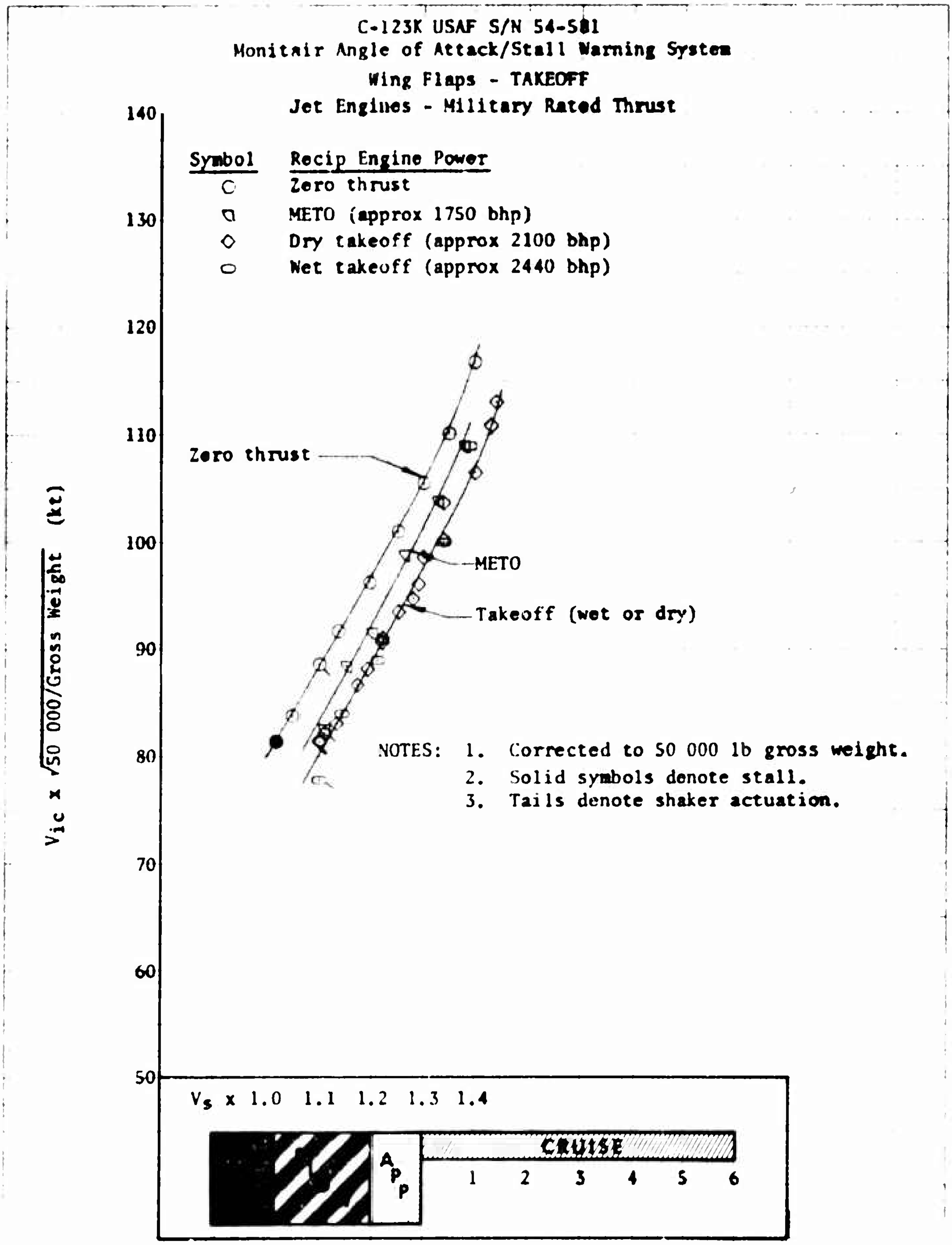


Figure 9. Stall Margin Indication vs Indicated Airspeed

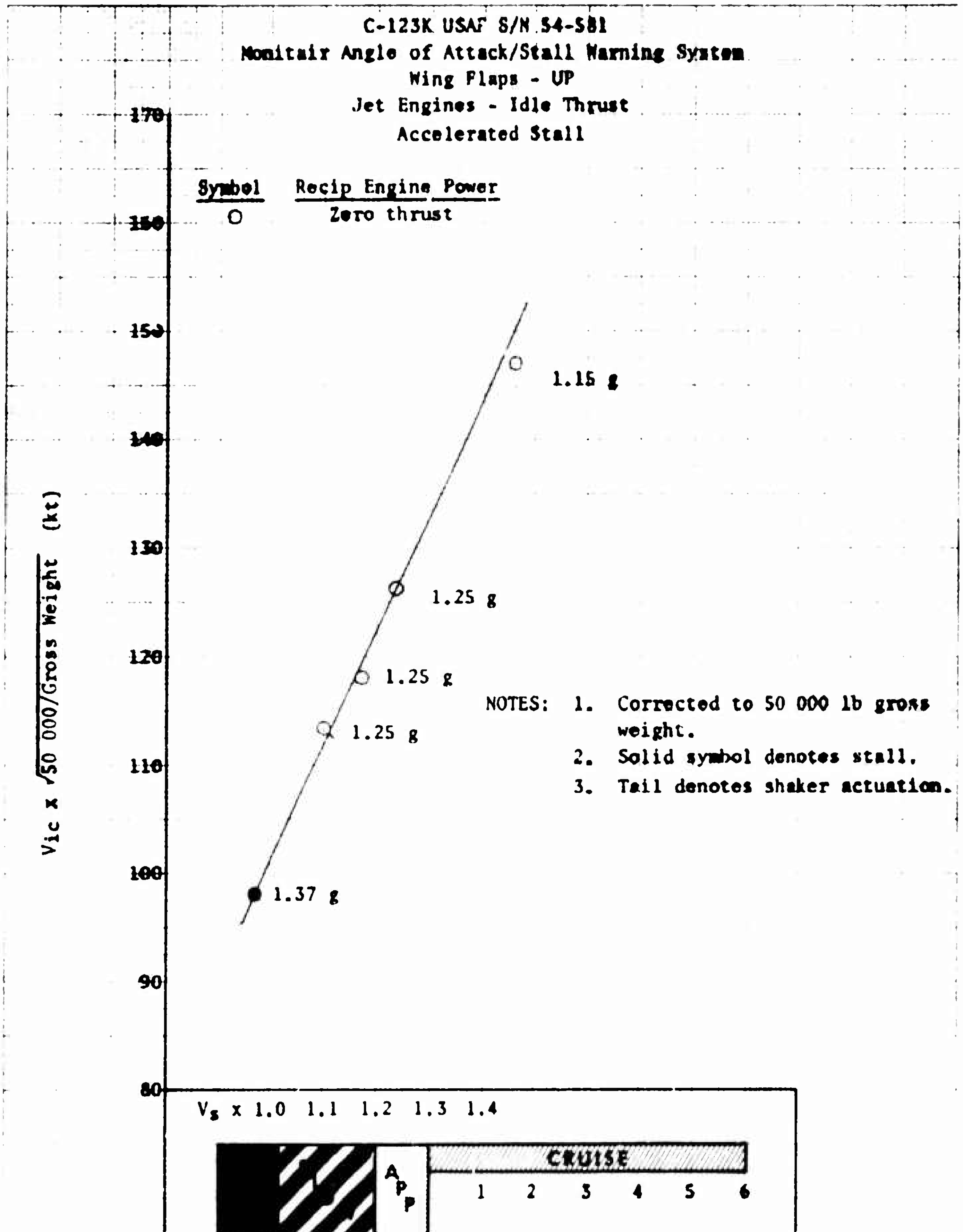


Figure .0. Stall Margin Indication vs Indicated Airspeed

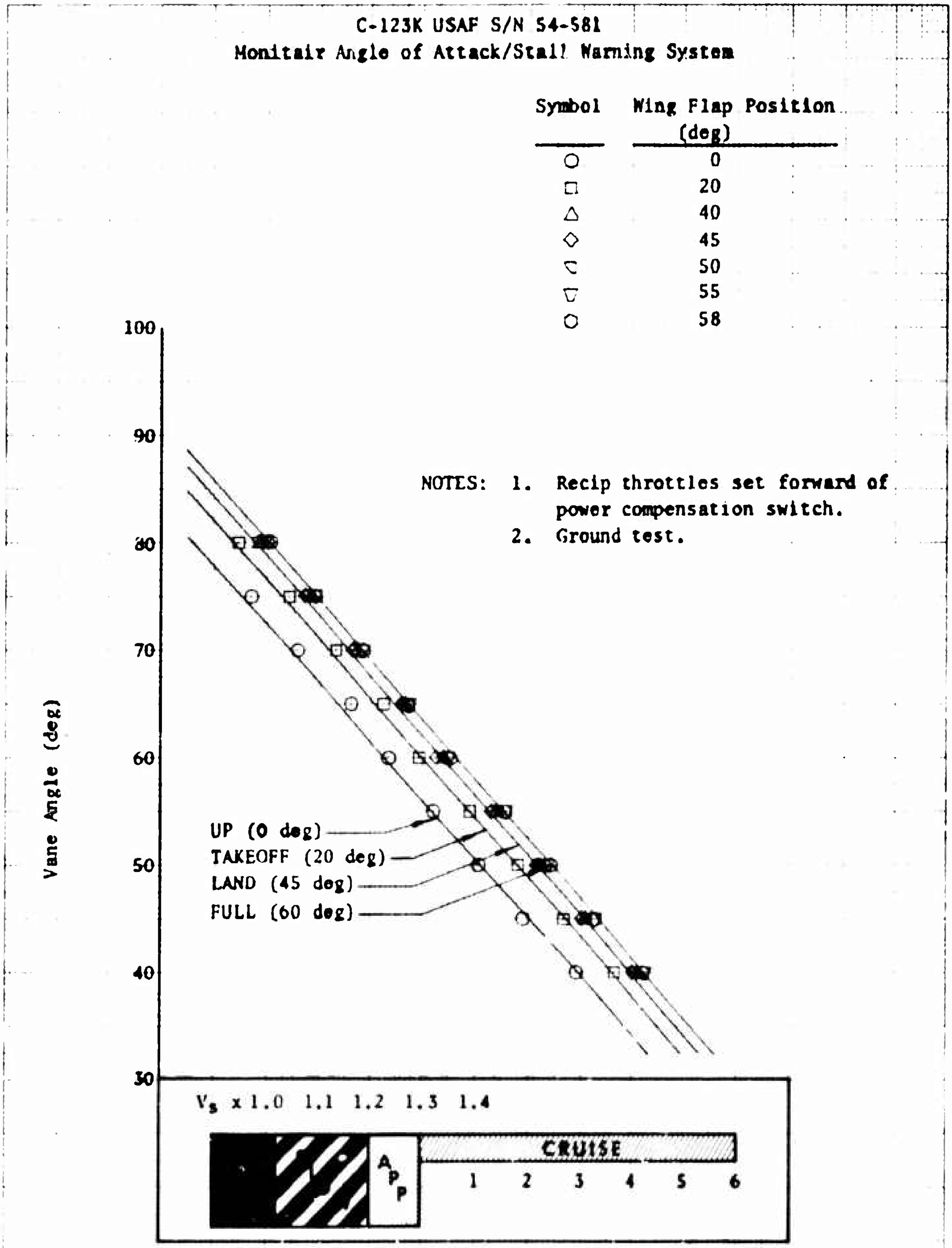


Figure 11. Stall Margin Indication vs Vane Angle

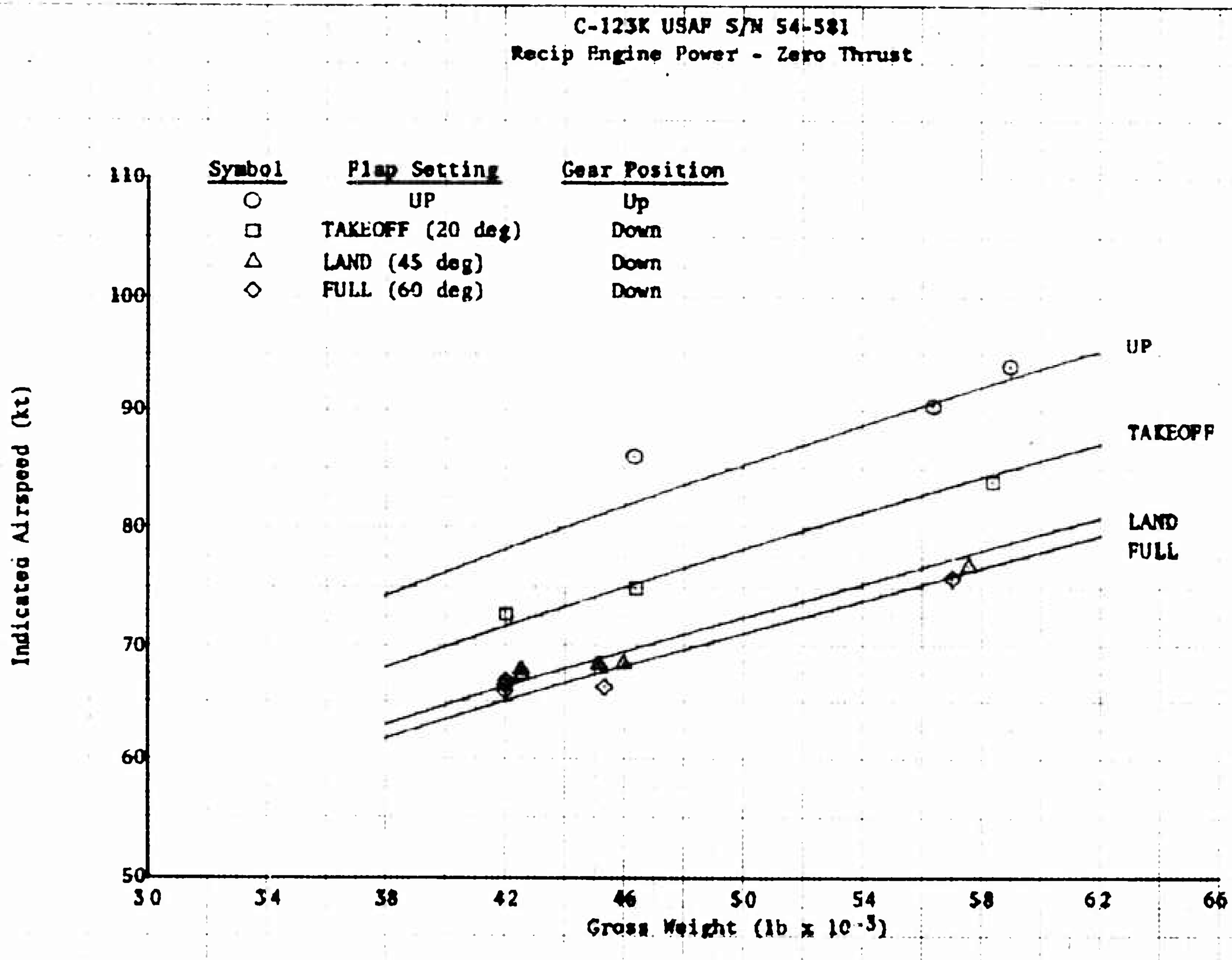


Figure 12. Stall Summary

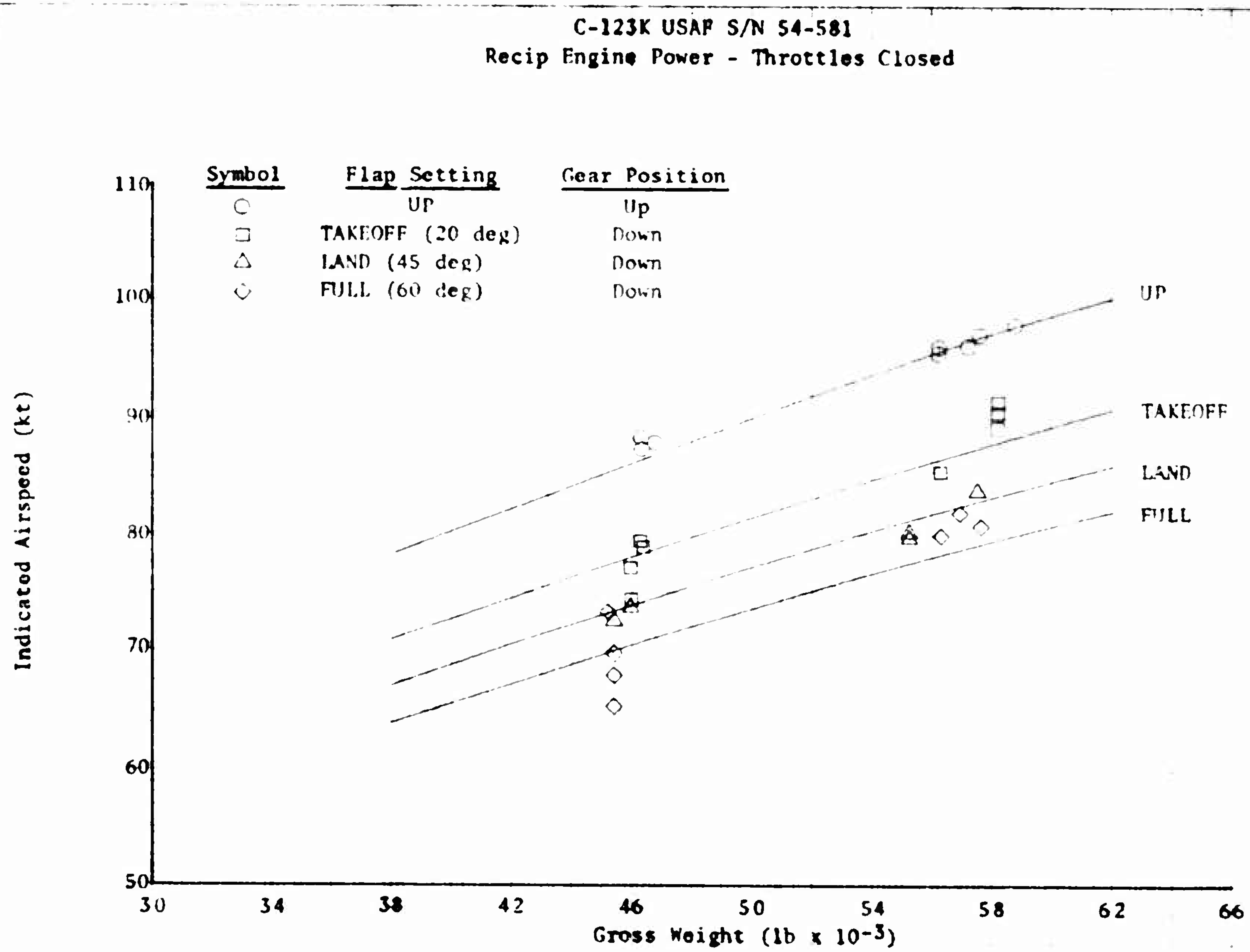


Figure 13. Stall Summary

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